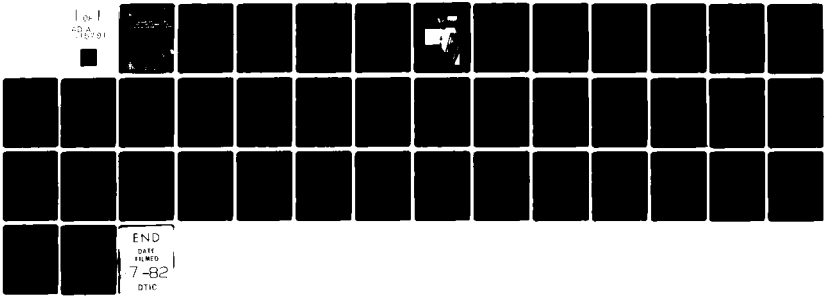
AD-A115 791 SYSTEMS AND APPLIED SCIENCES CORP MONTEREY CA F/G 4/2
SHIPBOARD TROPICAL CYCLONE APPLICATIONS SOFTWARE SYSTEM FOR THE--ETC(U)
APR 82 D CHIN N00228-81-C-H157

UNCLASSIFIED NEPRF-CR-82-07 NL



END
DATE FILMED
7-82
DTIC

NAVENVPREDRSCHFAC
CONTRACTOR REPORT
CR 82-07

SHIPBOARD TROPICAL CYCLONE APPLICATIONS SOFTWARE SYSTEM FOR THE WESTERN NORTH PACIFIC OCEAN

Prepared By:

Don Chin

Systems and Applied Sciences Corporation
Monterey, California 93940

Contract No. N00228-81-C-H157

APRIL 1982

Prepared For:
NAVAL ENVIRONMENTAL PREDICTION RESEARCH FACILITY
MONTEREY, CALIFORNIA 93940

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NAVENVPREDRSCHFAC Contractor Report CR 82-07	2. GOVT ACCESSION NO. A115791	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Shipboard Tropical Cyclone Applications Software System for the Western North Pacific Ocean		5. TYPE OF REPORT & PERIOD COVERED Final
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Don Chin		8. CONTRACT OR GRANT NUMBER(s) N00228-81-C-H157
9. PERFORMING ORGANIZATION NAME AND ADDRESS Systems and Applied Sciences Corporation 570 Casanova Avenue Monterey, CA 93940		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS PE 63207N PN 0W0 512-CC NEPRF WU 6.3-17
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Air Systems Command Department of the Navy Washington, DC 20361		12. REPORT DATE April 1982
		13. NUMBER OF PAGES 38
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) Naval Environmental Prediction Research Facility Monterey, CA 93940		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Tropical cyclones
Ship routing

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The shipboard Tropical Cyclone Applications Software System (TCASS) is described. TCASS is a set of microcomputer programs which displays and evaluates the tropical cyclone wind threat to a ship or unit. Tropical cyclone wind probability forecast methods for the western North Pacific Ocean, based on statistical analyses of historical tropical cyclone forecast errors, are used within TCASS. If the tropical cyclone wind threat exceeds a predefined threshold level, an alternative routing procedure ((continued on reverse))

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE S/N 0102-014-6601 |

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Block 20, Abstract, continued.

is invoked to reduce the threat level. Applications of the software are provided, and examples of the resulting output are included.

TABLE OF CONTENTS

SECTION 1. INTRODUCTION

1.1 Background. Tropical cyclone strike and wind probability forecast methods have been developed based on statistical analyses of historical Joint Typhoon Warning Center (JTWC), Guam tropical cyclone forecast errors for the western North Pacific Ocean as described in references [1] and [2]. These forecast techniques provide a quantified measure of the tropical cyclone wind threat to fixed points of interest, and have been adapted for use in developing a set of computer programs for Optimum Track Ship Routing (OTSR) applications which was reported in reference [3]. This OTSR applications software is currently installed on the large mainframe computer system at the Fleet Numerical Oceanography Center (FNOC), Monterey, California.

Similar software was needed for shipboard applications which allow independence from central site computer systems. As a result, the Tropical Cyclone Applications Software System (TCASS) was developed for the Naval Environmental Prediction Research Facility (NEPRF). The initial version of TCASS, applicable to the western North Pacific Ocean area, was written for the Hewlett-Packard (HP) 9845 and has been distributed to Pacific Fleet HP9845 equipped ships as Shipboard Numerical Aids Program (SNAP) No. 7.

A typical shipboard unit of the HP9845 desktop microcomputer, illustrated in Figure 1-01, has a keyboard, cathode ray tube (CRT), two tape cassette drives, a thermal printer, graphics capabilities, and 64K words of memory.

1.2 Capabilities. TCASS applies tropical cyclone wind probability forecast techniques based on the JTWC Guam tropical cyclone warnings to:

a. provide briefing aids
b. assist the shipboard user in evaluating the tropical

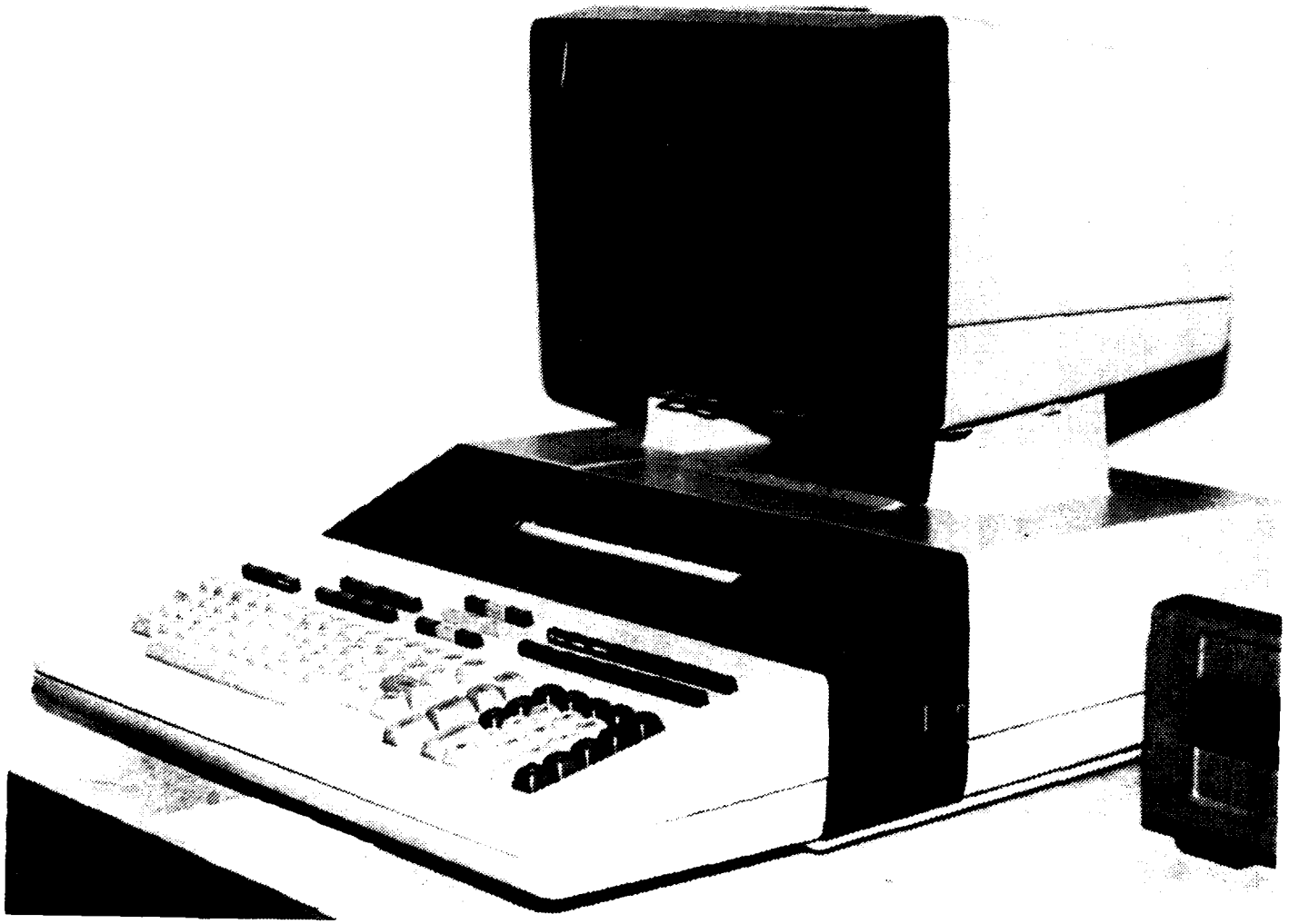


FIGURE 1-01. Typical HP9845 Microcomputer Unit

cyclone wind threat

c. assist in formulating a recommended course of action

To accomplish this, TCASS provides six options which perform six corresponding functions, as follows:

Option 1. Display the current tropical cyclone warning in graphic and alphanumeric form.

Option 2. Display the "danger" area[1] for the warning as defined by Annex H of the CINCPACFLT operation order No. 201.

Option 3. Display projected ship tracks beginning at the date-time-group of the warning for the duration of the warning period up to 72 hours.

Option 4. Evaluate a ship's projected track by calculating the instantaneous probabilities of encountering 30 and 50 kt tropical cyclone winds at 6 hour intervals along the ship's projected track for a given warning during the warning period.

Option 5. Calculate and display the user specified critical probability[2] isolines for 30 and/or 50 kt tropical cyclone winds at 24 hr intervals for the warning.

Option 6. Calculate and display the shortest route (auto-routing), from the ship's position at the beginning

---

[1] The CINCPACFLT "danger" area is determined from the JTWC warning by constructing the area of 30 kt winds at the warning time, the area of 30 kt winds at the 24 hr forecast position increased by a radius of 135 n mi, and connecting the two areas by tangent lines to produce a contiguous area.

[2] Critical probabilities are those threshold values designated by the user which, if exceeded, constitutes an unaccepted level of risk. For example, a critical probability of 10% indicates a 90% probability of avoiding the occurrence of the event is acceptable.

of the warning period toward a position designated by the user, which does not exceed the user specified critical probabilities of 30 and 50 kt tropical cyclone winds during the period of the warning.

SECTION 2. DESCRIPTION

2.1 Modes of Operation. TCASS operates in two modes:

a. semi-automatic mode
b. selective mode

Semi-automatic mode. In this mode, TCASS performs all six functions described in the previous section. A minimum of user interaction is necessary and is mainly performed at the beginning of processing in order to enter data. However, this mode limits the processing to one tropical cyclone warning and one projected ship track during each run. Results are displayed and hard copies of the products are provided automatically.

Selective mode. The selective mode allows the user a wider range of flexibility. The six options, corresponding to the functions performed by TCASS, may be selected individually or in combination as desired by the user during a given TCASS run in this mode. Up to three tropical cyclone warnings may be processed. Any number of projected ship tracks may be displayed at the option of the user. However, only one ship at a time may be evaluated or auto-routed for each tropical cyclone warning. TCASS also allows the user to obtain hard copies of the output as desired. Upon completion of program execution in either mode the user may re-run the program selecting a different mode or different options in the selective mode.

2.2 Map Background. The total area of coverage for TCASS graphic displays extends from 3°N to 37°N, 105°E to 175°E. Because of the limitations of the graphic display area, coverage of the above area is provided by two overlapping backgrounds, a left panel and a right panel. These are illustrated in Figures 2-01 and 2-02, respectively. The user may select either panel, otherwise the left panel will be used by default.

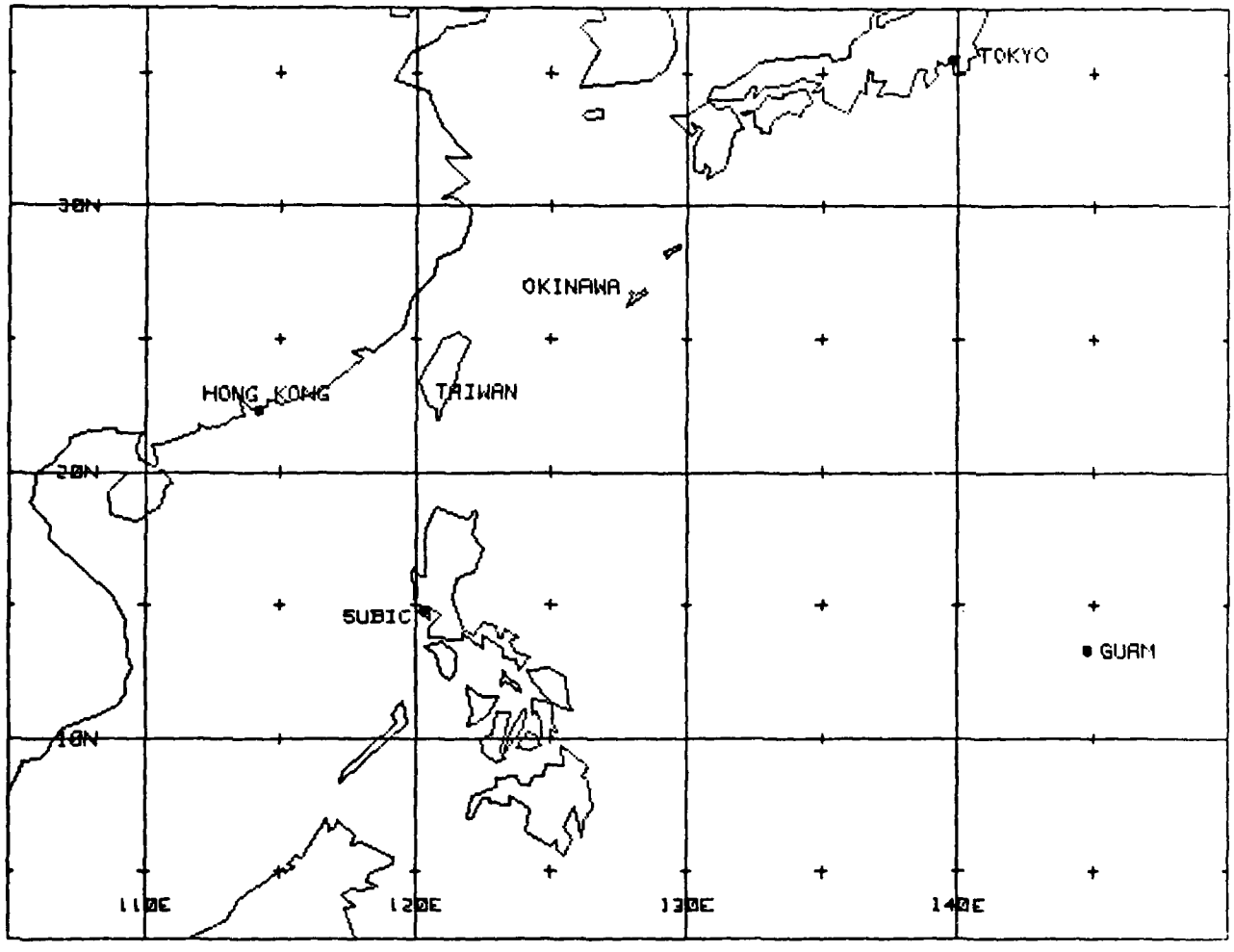


FIGURE 2-01. Geographic Background - Left Panel.

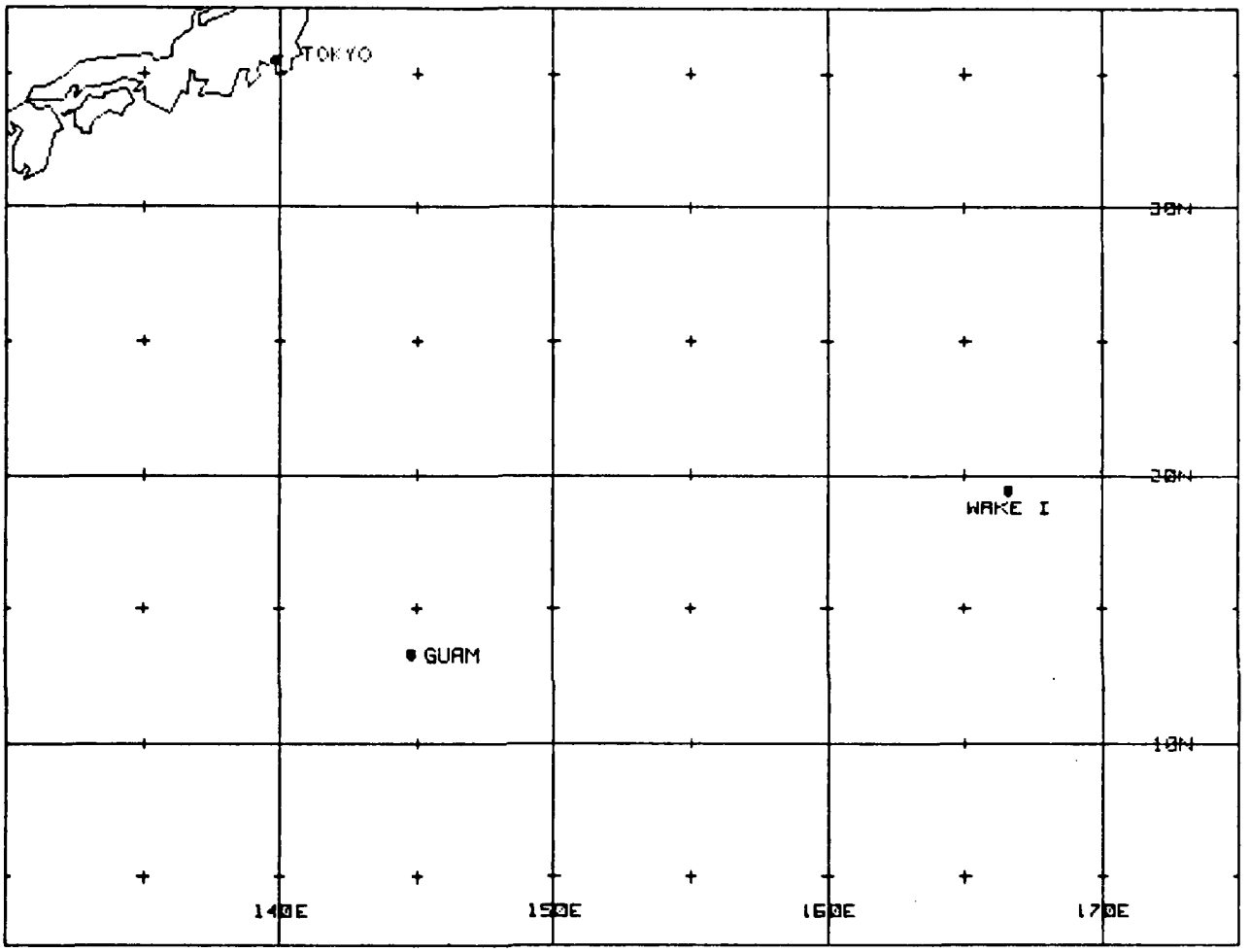


FIGURE 2-02. Geographic Background - Right Panel .

SECTION 3. PROGRAM OPERATION

3.1 General. Detailed operating instructions for TCASS are contained in the TCASS Users Manual, reference [4]. This section covers the input data needed in the operation of TCASS, the processing of each function and the resulting outputs.

3.2 Input Data. To operate TCASS certain input data are needed. The program prompts the user on the information required (depending on the mode of operation and options selected), and the format of the data entries. The current JTWC Guam tropical cyclone warning(s), the ship's position at warning time, and other ship information such as speed of advanced and course or projected track are normally required. The critical probabilities (threshold values) of 30 and 50 kt tropical cyclone winds, respectively, may also be necessary. These user defined critical probabilities indicate the level of risk that is considered acceptable for the operating circumstances. In the absence of user specified critical values, the program assigns (by default) values of 5% and 3% probabilities of 30 and 50 kt tropical cyclone winds, respectively. The above default values may be interpreted to mean a 95% and 97% level of confidence of avoiding 30 and 50 kt winds.

3.3 Processing and Output. TCASS processing depends on the operating mode and options selected. Each option and the resulting output are described in this subsection.

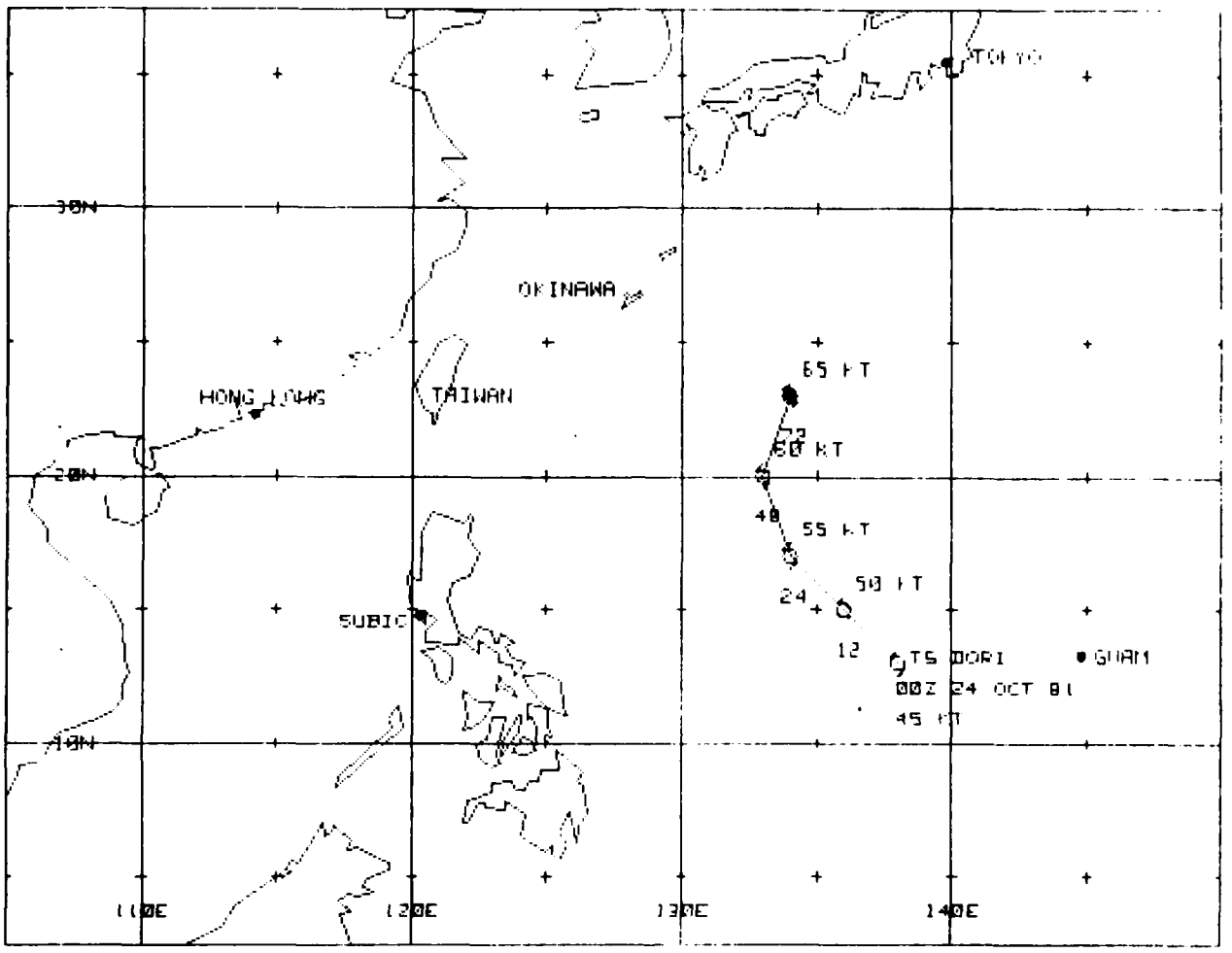
Option 1. Display tropical cyclone warning(s). To accomplish this, TCASS requests the necessary JTWC tropical cyclone warning data and plots the current, 12, 24, 48 and 72 hour warning positions (as available) of the tropical cyclone using the appropriate tropical cyclone symbols, with the

projected warning track connecting the warning positions. Appropriate annotations of the tropical cyclone stage, cyclone name or number, the warning date-time, and the maximum winds for each position are provided. An example of the display resulting from the selection of Option 1 is shown in Figure 3-01.

Option 2. Display "danger" area(s). Upon selection of this option, Option 1 is automatically selected, if not already specified, to request the necessary warning data and plot the tropical cyclone warning(s). The "danger" area, described earlier, is constructed and plotted. Figure 3-02 illustrates the result of selecting Option 2.

Option 3. Display ship track(s). With this option, the user is prompted to enter ship information consisting of the ship's call sign or 4 character designator, position at warning time, average speed, and the ship's projected track in the form of a base course or up to 4 additional positions which define the projected track. Using this information the ship's projected track is calculated at 6 hour intervals and plotted. An example is provided in Figure 3-03. The initial position of the track, subsequent 24 hourly positions, and final position are designated by an "X", with the > symbol designating the 6 hourly intermediate positions and direction of movement. An alphanumeric tabular display is also available as shown in Figure 3-04.

Option 4. Evaluate ship's projected track. When this option is invoked, the program requests the tropical cyclone warning data and ship's data as in Options 1 and 3. Once these data are entered and the user designated critical probabilities specified, if different from the default values, the program calculates the instantaneous probabilities of encountering 30 and 50 kt tropical cyclone winds at 6 hour intervals along the projected track. If the critical values



WARNING DTG: 122 24 OCT 81

TROPICAL STORM DORI WARNING NR 4 DIR SPD 310 DEGREES 9 KTS
00 HR INITIAL POSITION 1300N 13800E MAX WIND 45 KT
RADIUS OF 30 KT WINDS 100 MILES NE SEMICIRCLE, 75 MILES ELSEWHERE
12 HR FORECAST POSITION 1500N 13600E MAX WIND 50 KT
24 HR FORECAST POSITION 1700N 13400E MAX WIND 55 KT
RADIUS OF 50 KT WINDS 30 MILES
RADIUS OF 30 KT WINDS 150 MILES NE SEMICIRCLE, 100 MILES ELSEWHERE
48 HR FORECAST POSITION 2000N 13300E MAX WIND 60 KT
RADIUS OF 50 KT WINDS 50 MILES
72 HR FORECAST POSITION 2300N 13400E MAX WIND 65 KT
RADIUS OF 50 KT WINDS 75 MILES

FIGURE 3-01. Example of Option 1 output showing the tropical cyclone warning display in graphic and alphanumeric form.

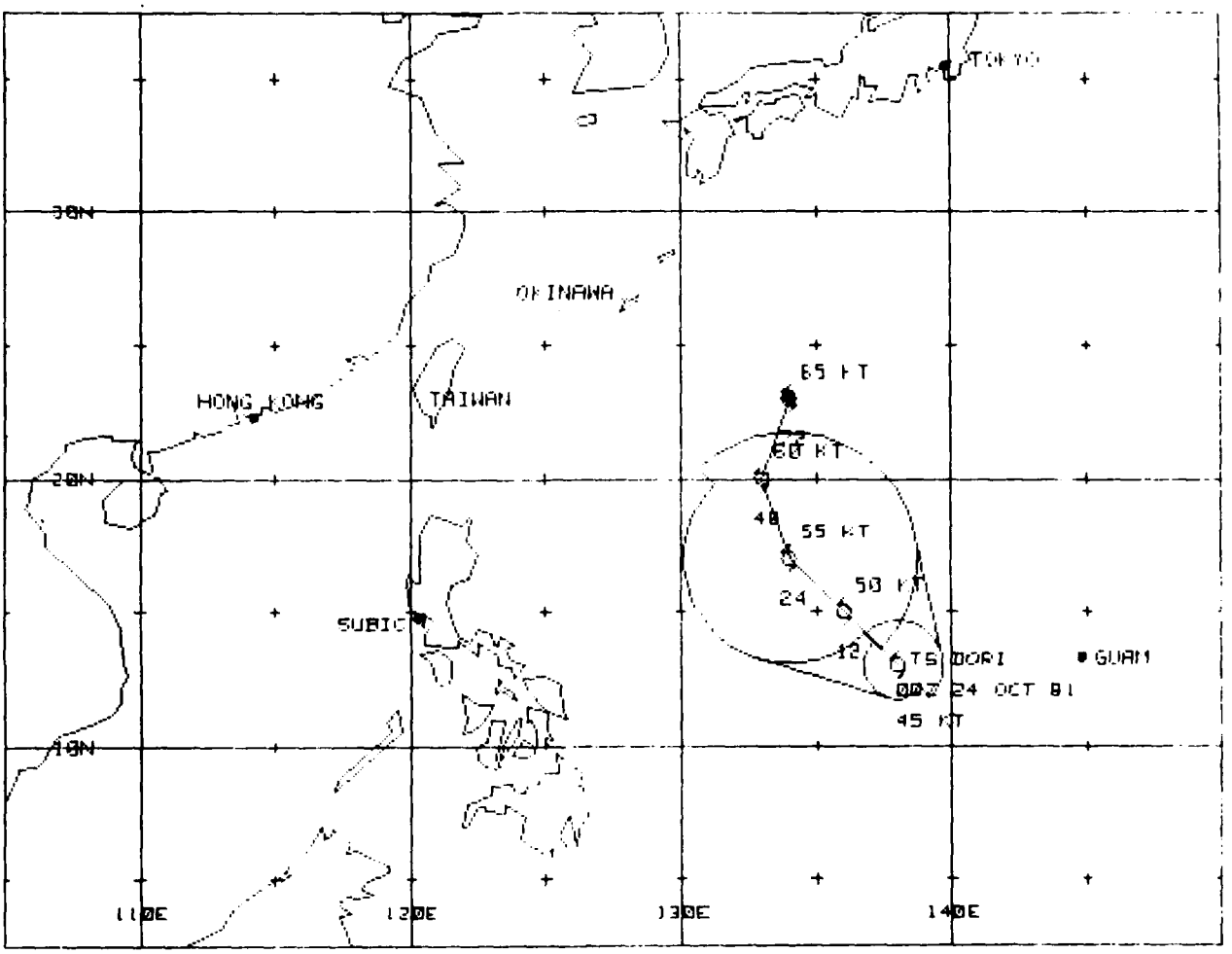


FIGURE 3-02. Example of Option 2 output consisting of a graphic display of the tropical cyclone warning and "danger" area .

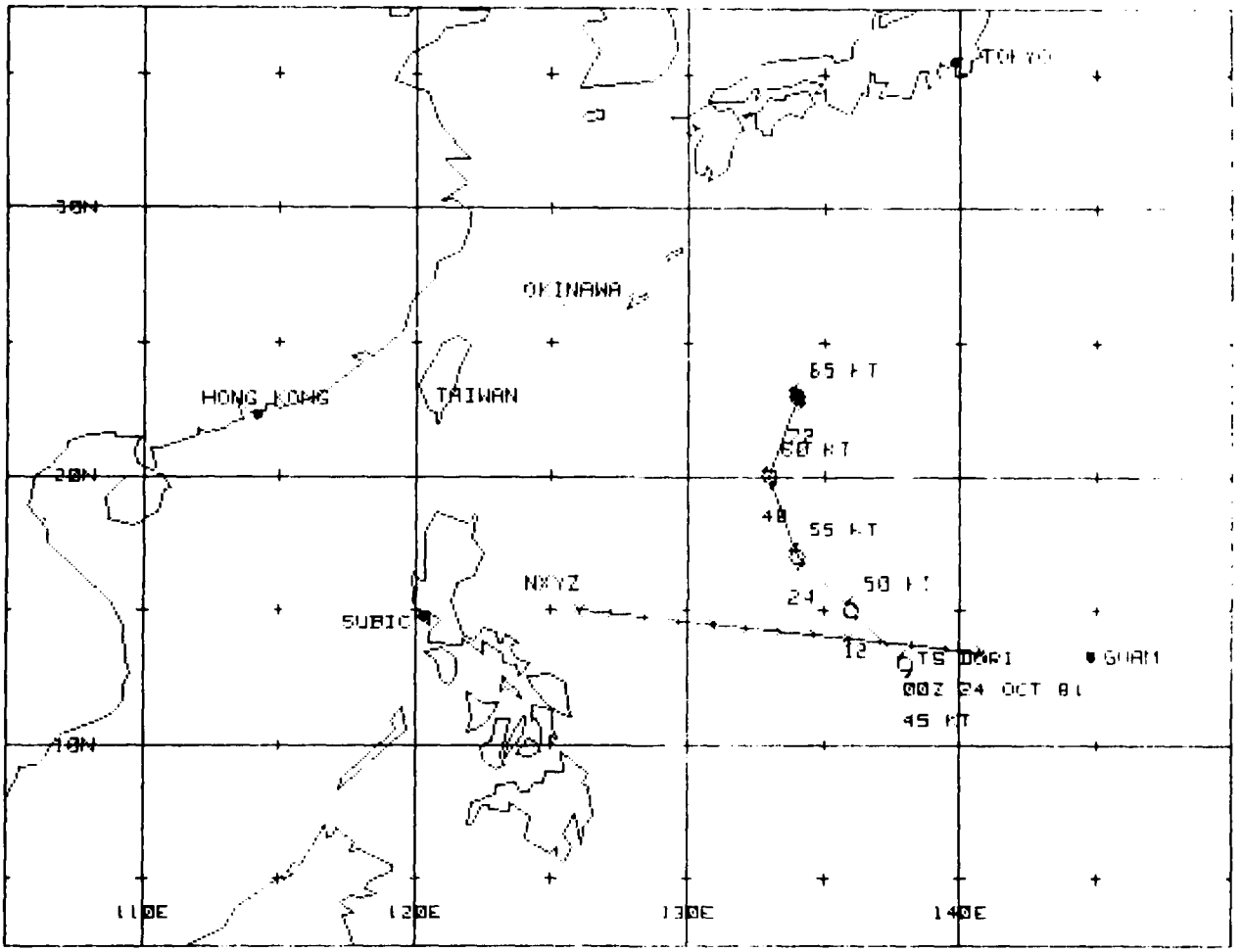


FIGURE 3-03. Example of Option 3 graphic display of the ship's projected track at six hour intervals, along with the tropical cyclone warning (Option 1).

SHIP'S ID: NIMZ
SHIP'S SPEED: 12 KT
DTG: 00Z 24 OCT 81

PT 1 15.0N 126.0E
PT 2 13.4N 140.8E

TAU	LAT	LONG
0	15.0N	126.0E
6	14.9N	127.2E
12	14.7N	128.5E
18	14.6N	129.7E
24	14.5N	130.9E
30	14.4N	132.2E
36	14.2N	133.4E
42	14.1N	134.6E
48	14.0N	135.9E
54	13.8N	137.1E
60	13.7N	138.3E
66	13.6N	139.5E
72	13.4N	140.8E

FIGURE 3-04. Example of alphanumeric listing of ship's projected track at six hour intervals (Option 3).

are exceeded, a message to this effect is provided. An alphanumeric display of the results is illustrated in Figure 3-05.

Please note that a stationary ship (speed of 0) may be used to simulate a fixed geographic location such as a port or structure for the tropical cyclone wind threat evaluation.

Option 5. Display critical probability isolines (isopleths). This option invokes Option 1 and uses the tropical cyclone warning data to calculate the critical probability isolines of 30 and/or 50 kt tropical cyclone winds at 24 hour intervals based on the warning data. An example showing the isolines for 30 and 50 kt winds superimposed on the tropical cyclone warning display is provided in Figure 3-06. The areas within the solid and dashed lines exceed the designated threshold values for the wind speeds of 30 and 50 kt, respectively, at the corresponding 24 hourly intervals.

Option 6. Automatic routing of ship. The selection of Option 6 alone, automatically invokes Options 1 and 4. This option provides the capability of calculating an alternative route if the projected ship's track, evaluated in Option 4, exceeds the critical probabilities. This alternative route may be one which proceeds along the original track but at a slower speed to allow the tropical cyclone to pass ahead of the projected ship movement, or failing this approach, attempts to circumnavigate the areas of high risk at the original average speed. The resulting route, if one can be found within the program constraints, is the shortest route which does not exceed the user designated critical values, beginning from the ship's position at the current warning date-time toward the user specified destination or secondary position during the warning period (up to 72 hours). Figure 3-07 illustrates the tropical cyclone warning (Option 1), the original ship's projected track (solid line), as a result of Option 4, and the alternative route (dashed line). Also

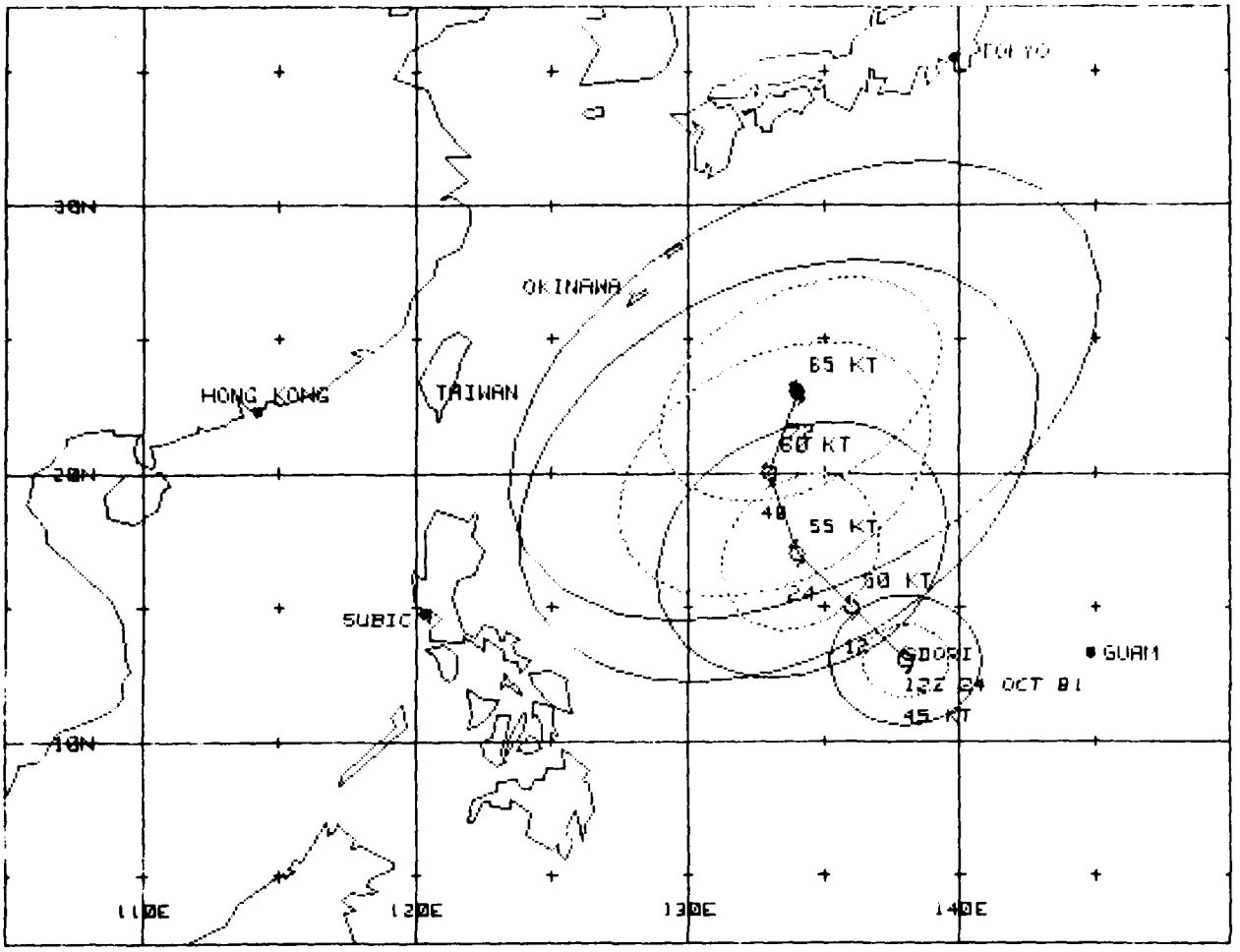
SHIP TRACK EVALUATION

SHIP'S ID: NXYZ
SHIP'S SPEED: 12 KT DIST: 864 NMI
WARNING DTG: 00Z 24 OCT 81 TROPICAL STORM DOPI

TIME	LAT	LONG	PROBABILITIES 30 KT WINDS	50 KT WINDS
0	15.0N	126.0E	0.0	0.0
6	14.9N	127.2E	.0	0.0
12	14.7N	128.5E	.0	0.0
18	14.6N	129.7E	2.5	.1
24	14.5N	130.9E	9.6	1.4
30	14.4N	132.2E	12.1	2.2
36	14.2N	133.4E	9.3	1.4
42	14.1N	134.6E	6.4	.8
48	14.0N	135.9E	5.9	.8
54	13.8N	137.1E	3.2	.4
60	13.7N	138.3E	1.8	.2
66	13.6N	139.5E	1.1	.1
72	13.4N	140.8E	.5	.1

CRITICAL PROBABILITIES EXCEEDED

FIGURE 3-05. Example of Option 4 alphanumeric listing of ship evaluation showing the six hourly positions and corresponding wind probabilities.



5% PROBABILITY ISOPLETHS OF 30KT WINDS (SOLID LINES)
3% PROBABILITY ISOPLETHS OF 50KT WINDS (DASHED LINES)

FIGURE 3-06. Example of Option 5 illustrating the instantaneous critical probability isolines (isopleths) of 30 and 50 kt tropical cyclone winds.

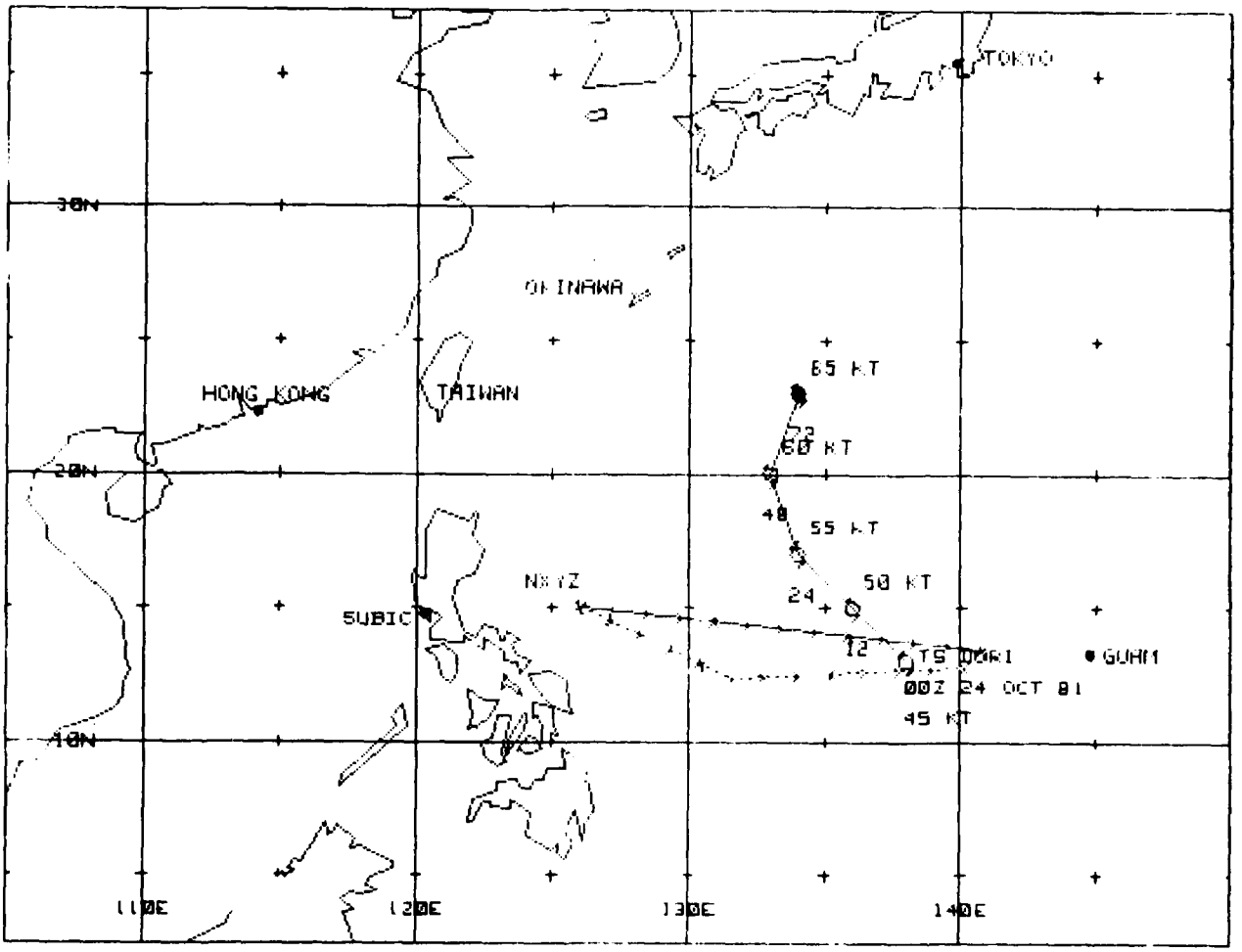


FIGURE 3-07. Example of Option 6 showing alternative route (dashed lines) as well as tropical cyclone warning and original ship's projected track (solid lines).

provided is an alphanumeric listing (shown in Figure 3-08) of the alternative route with the probabilities of 30 and 50 kt tropical cyclone winds at 6 hour intervals.

If the evaluation of the ship's projected track (Option 4) shows that the projected track is non-critical (does not exceed the critical values along the ship's track), Option 6 is cancelled.

ALTERNATE ROUTE
BEGINNING POSITION: 15.0N 126.0E
INTENDED POSITION: 13.0N 145.0E

SHIP'S ID: NXYZ
SHIP'S SPEED: 12 KT DIST: 864 NMI
WARNING DTG: 00Z 24 OCT 81 TROPICAL STORM DORI

TIME	LAT	LONG	PROBABILITIES 30 KT WINDS	50 KT WINDS
0	15.0N	126.0E	0.0	0.0
6	14.5N	127.1E	.0	0.0
12	13.9N	128.2E	.0	0.0
18	13.4N	129.3E	1.4	.0
24	12.9N	130.4E	3.3	.4
30	12.4N	131.5E	3.8	.4
36	12.4N	132.8E	3.6	.4
42	12.5N	134.0E	3.1	.3
48	12.5N	135.2E	3.3	.4
54	12.6N	136.5E	.1	.2
60	12.6N	137.7E	3	.1
66	12.7N	138.9E	8	.1
72	12.8N	140.1E	5	.1

FIGURE 3-08. Example of alphanumeric listing of alternative route provided as output of Option 6.

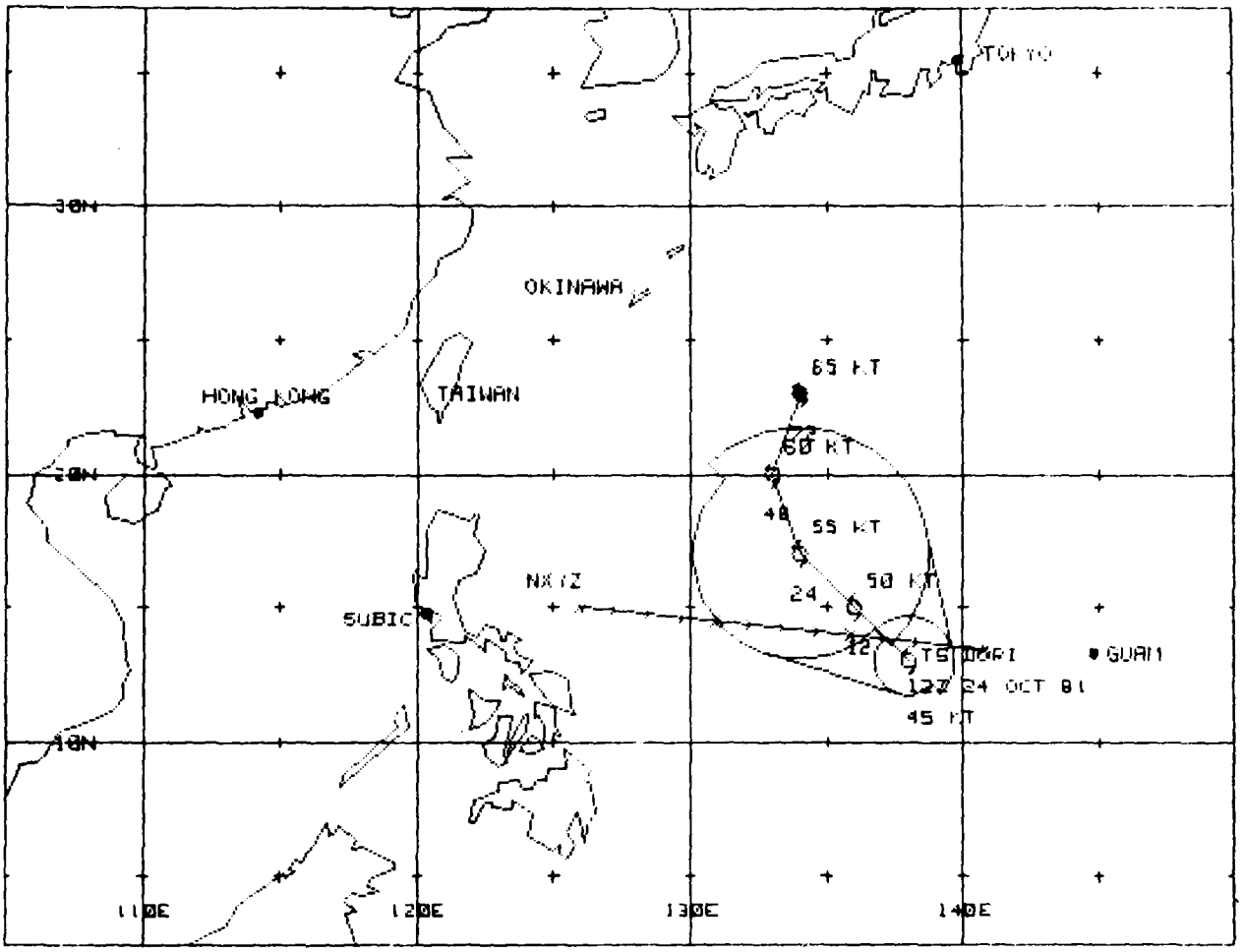
SECTION 4. APPLICATIONS

4.1 General. TCASS is a highly versatile tool which assists the shipboard user when one or more tropical cyclones pose a possible threat. Understanding of the capabilities, modes of operation and option selections allows the user to take maximum advantage of TCASS. Examples of the semi-automatic mode and other applications of TCASS are provided in this section.

4.2 Semi-automatic Mode. This mode is useful for the scenario which probably occurs most often; when only one tropical cyclone warning is in effect and the only concern of the user is a single ship route or location. The requirement for user interaction is minimized and occurs mostly at the beginning of the program. The output is fixed, with the user controlling the number of hard copies. Output examples are shown in Figures 4-01 through 4-03.

Options 1, 2, and 3 are processed initially, resulting in the graphic product shown in Figure 4-01. This product shows the tropical cyclone warning for a tropical storm in graphic and alphanumeric form, the "danger" area, and the ship's projected track. In this example, ship NXYZ is proceeding from a position east of Luzon, Philippine Islands toward Guam. Because no wind probability calculations are required thus far, the whole process takes approximately 3 minutes exclusive of data entry time, with tape reading processes and plotting of the map background consuming most of this time.

Options 3, 4, and 5 are then performed. The ship track evaluation is displayed in alphanumeric form and the user specified critical probability isopleths of 30 kt winds plotted, along with the tropical cyclone warning and ship's projected track (Figure 4-02). In this example, the projected



WARNING DTG: 12Z 24 OCT 81

TROPICAL STORM DORI WARNING NR 4 DIR SPD 310 DEGREES 9 KTS
00 HR INITIAL POSITION 1300N 13800E MAX WIND 45 KT
RADIUS OF 30 KT WINDS 100 MILES NE SEMICIRCLE, 75 MILES ELSEWHERE
12 HR FORECAST POSITION 1500N 13600E MAX WIND 50 KT
24 HR FORECAST POSITION 1700N 13400E MAX WIND 55 KT
RADIUS OF 50 KT WINDS 30 MILES
RADIUS OF 30 KT WINDS 150 MILES NE SEMICIRCLE, 100 MILES ELSEWHERE
48 HR FORECAST POSITION 2000N 13300E MAX WIND 60 KT
RADIUS OF 50 KT WINDS 50 MILES
72 HR FORECAST POSITION 2300N 13400E MAX WIND 65 KT
RADIUS OF 50 KT WINDS 75 MILES

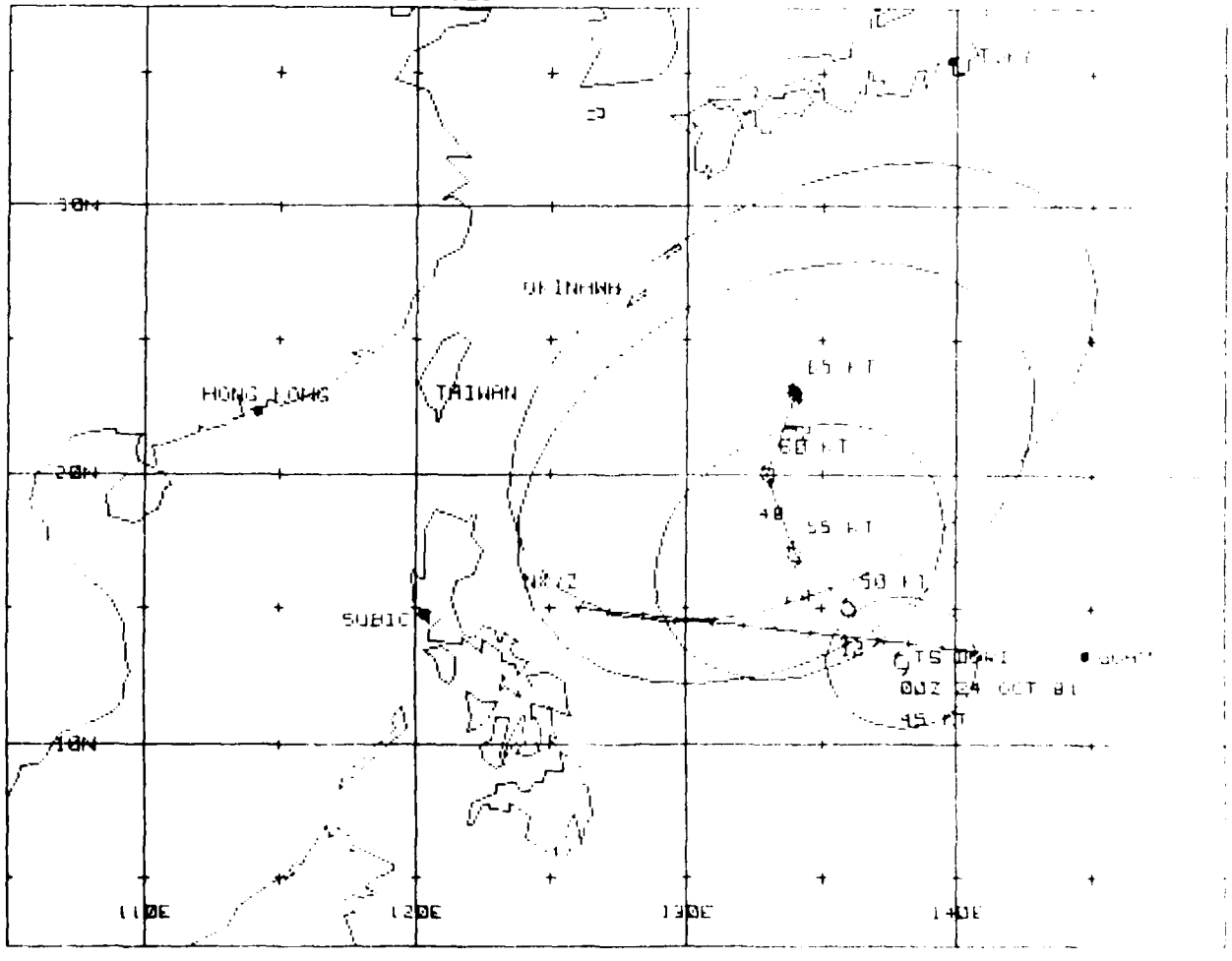
FIGURE 4-01. Example of output as a result of Options 1, 2, and 3 in the semi-automatic mode.

SHIP TRACK EVALUATION

SHIP'S ID: NSYZ
SHIP'S SPEED: 12 KT DIST: 864 NMI
WARNING DTG: 00Z 24 OCT 81 TROPICAL STORM DORI

TIME	LAT	LONG	PROBABILITIES 30 KT WINDS	50 KT WINDS
0	15.0N	126.0E	0.0	0.0
6	14.9N	127.2E	.0	0.0
12	14.7N	128.5E	.0	0.0
18	14.6N	129.7E	2.5	.1
24	14.5N	130.9E	9.6	1.4
30	14.4N	132.2E	12.1	2.2
36	14.2N	133.4E	9.3	1.4
42	14.1N	134.6E	6.4	.8
48	14.0N	135.9E	5.9	.8
54	13.8N	137.1E	3.2	.4
60	13.7N	138.3E	1.8	.2
66	13.6N	139.5E	1.1	.1
72	13.4N	140.8E	.5	.1

CRITICAL PROBABILITIES EXCEEDED



5% PROBABILITY ISOPLETHS OF 30KT WINDS (SOLID LINES)

FIGURE 4-02. Example of output provided by Options 4 and 5 in the semi-automatic mode.

ALTERNATE ROUTE
BEGINNING POSITION; 15.0N 126.0E
INTENDED POSITION: 13.0N 145.0E

SHIP'S ID: NXYZ
SHIP'S SPEED: 12 KT DIST: 864 NMI
WARNING DTG: 12Z 24 OCT 81 TROPICAL STORM DORI

TIME	LAT	LONG	PROBABILITIES 30 KT WINDS	50 KT WINDS
0	15.0N	126.0E	0.0	0.0
6	14.5N	127.1E	.0	0.0
12	13.9N	128.2E	.0	0.0
18	13.4N	129.3E	1.4	.0
24	12.9N	130.4E	3.3	.4
30	12.4N	131.5E	3.8	.4
36	12.4N	132.8E	3.6	.4
42	12.5N	134.0E	3.1	.3
48	12.5N	135.2E	3.3	.4
54	12.6N	136.5E	2.1	.2
60	12.6N	137.7E	1.3	.1
66	12.7N	138.9E	.8	.1
72	12.8N	140.1E	.5	.1

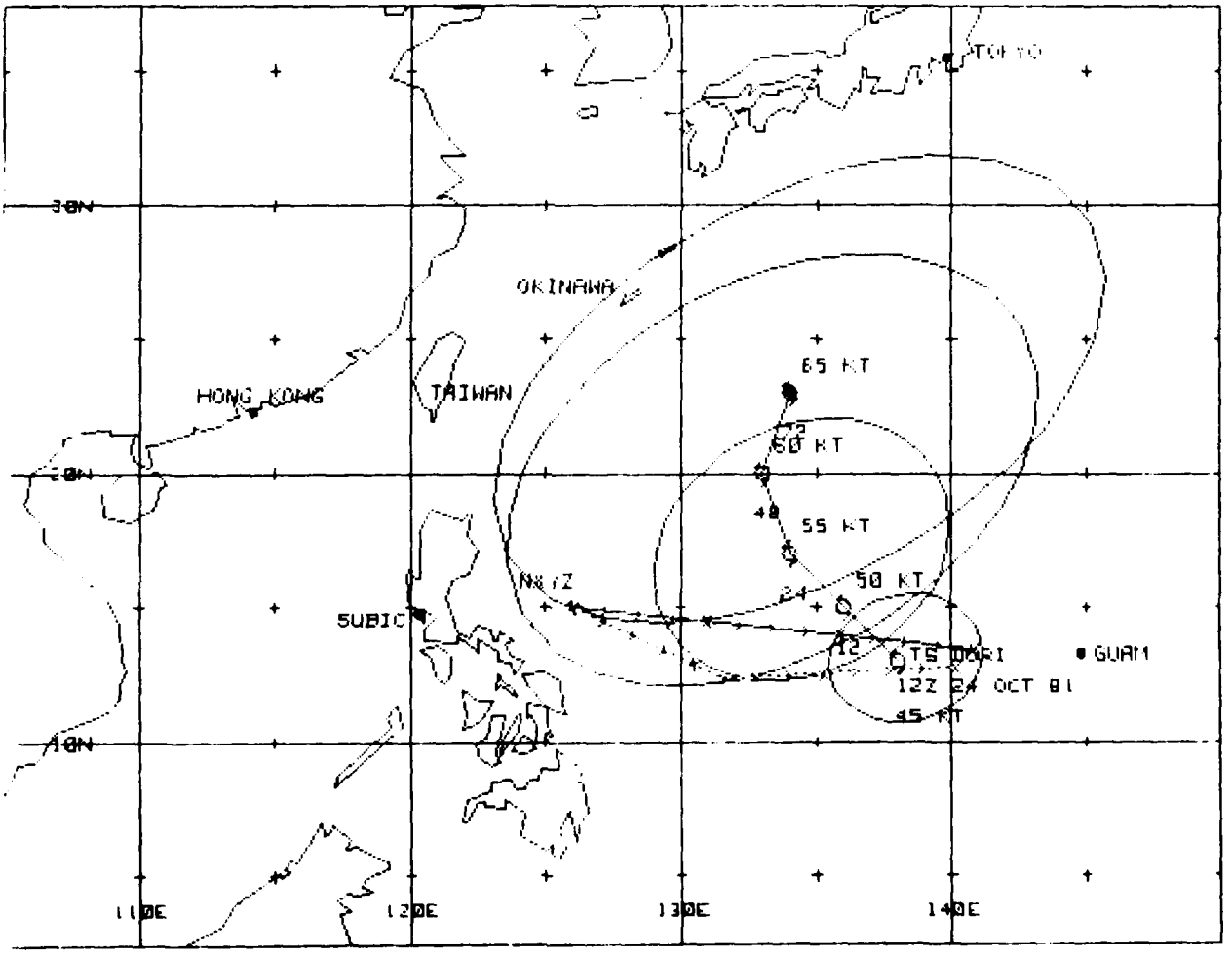


FIGURE 4-03. Example of output produced by Option 6 in the semi-automatic mode.

ship's track exceeds the critical values; alternative routing is invoked. The user specifies the ship's destination or secondary position toward which the routing is desired and the program proceeds with the alternative routing. The resulting route is listed in alphanumeric form and the alternate route plotted as a dashed line on the same display as above. The resulting product is illustrated in Figure 4-03.

Processing of Option 4 takes 1½-2 minutes. Option 5 requires from 5 to 9 minutes depending on whether the 30 or 50 kt isopleths are selected or both, and the duration of the warning. Option 6 expends another 1-2 minutes if invoked.

4.3 Other Applications. Figures 4-04 through 4-10 show additional TCASS applications. A description of each example accompanies the illustration.

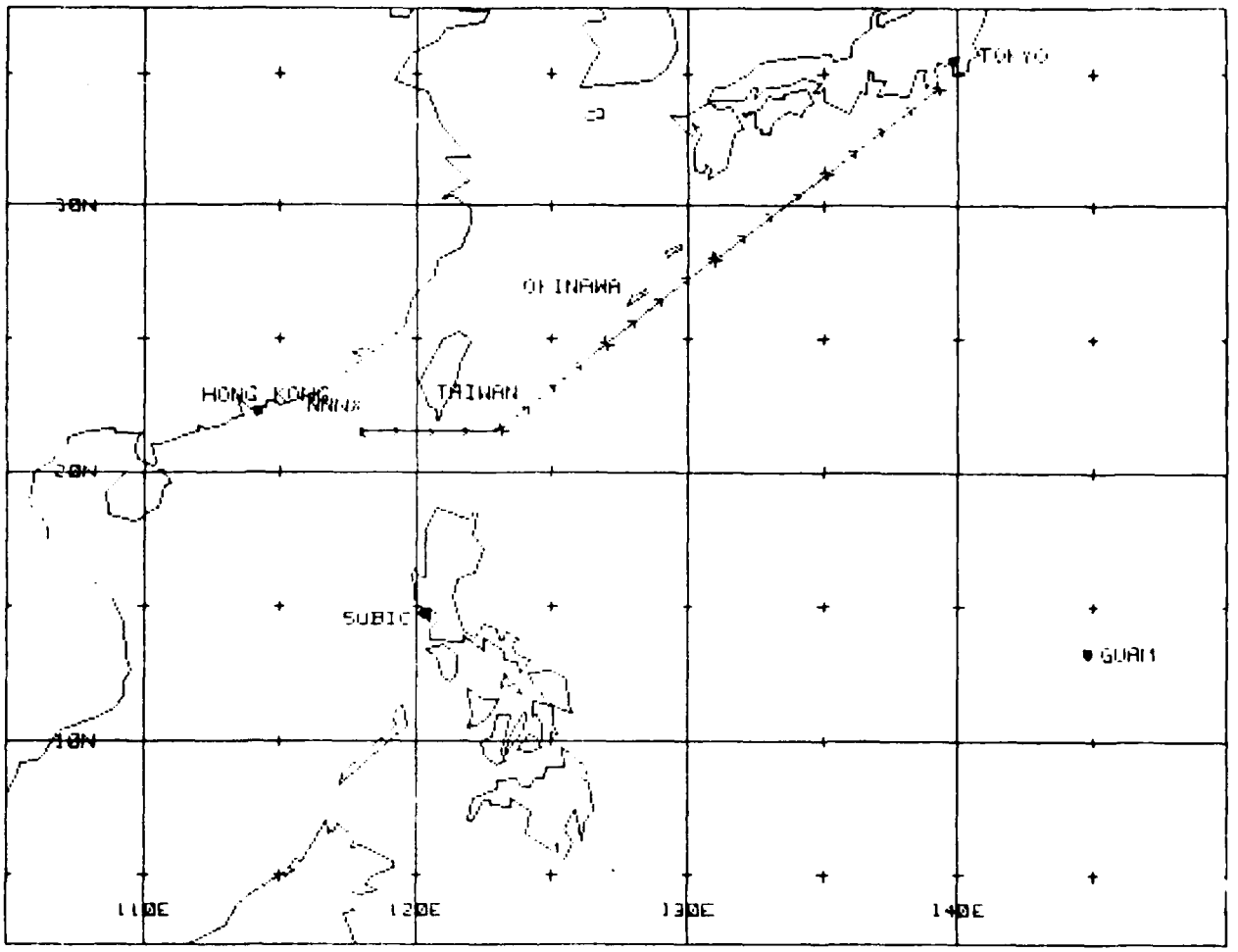


FIGURE 4-04. This example shows a use of TCASS for briefing and display purpose only, with no TC warnings in effect. The 120 hour track for ship "NNNX" enroute to Yokosuka, Japan at 15 kts is depicted. This was produced in the selective mode, with Option 3. The ship was plotted as 2 ships. The first from the vicinity of Hong Kong to a point southeast of Taiwan, and then northeastward toward Yokosuka. The route was continued by plotting a second ship with a call sign of "bbbb" (4 blanks in quotes) from the 48 hour position toward Yokosuka for another 72 hours.

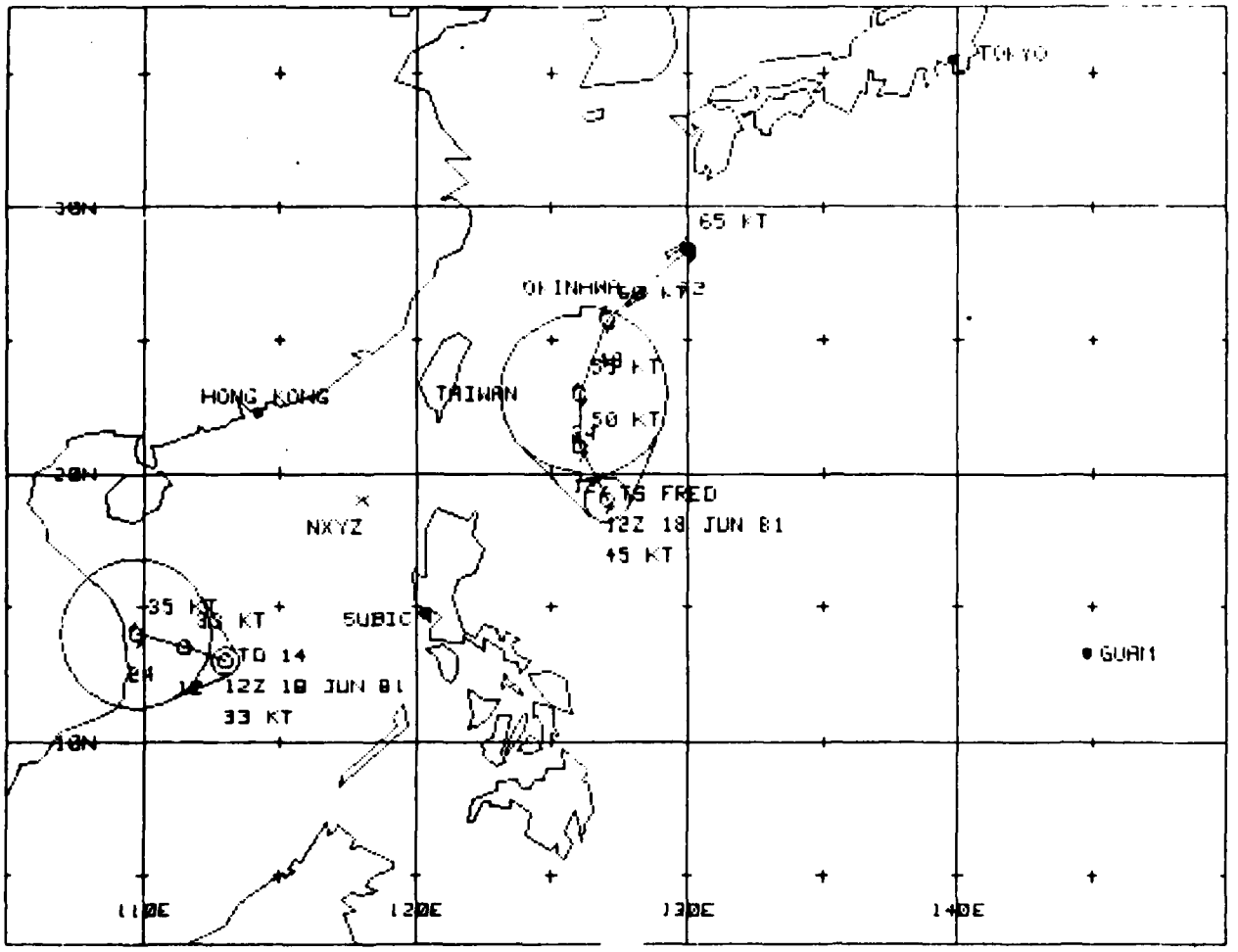


FIGURE 4-05. This display illustrates an example of ship "NYYZ" operating in the vicinity of 19°00'N, 118°00'E with two tropical cyclone warnings in effect (TD14 and tropical storm FRED). The "danger" areas for the respective tropical cyclones are shown. This example, obtained in the selective mode using Options 1, 2, and 3, is appropriate for qualitative evaluation and briefing purposes.

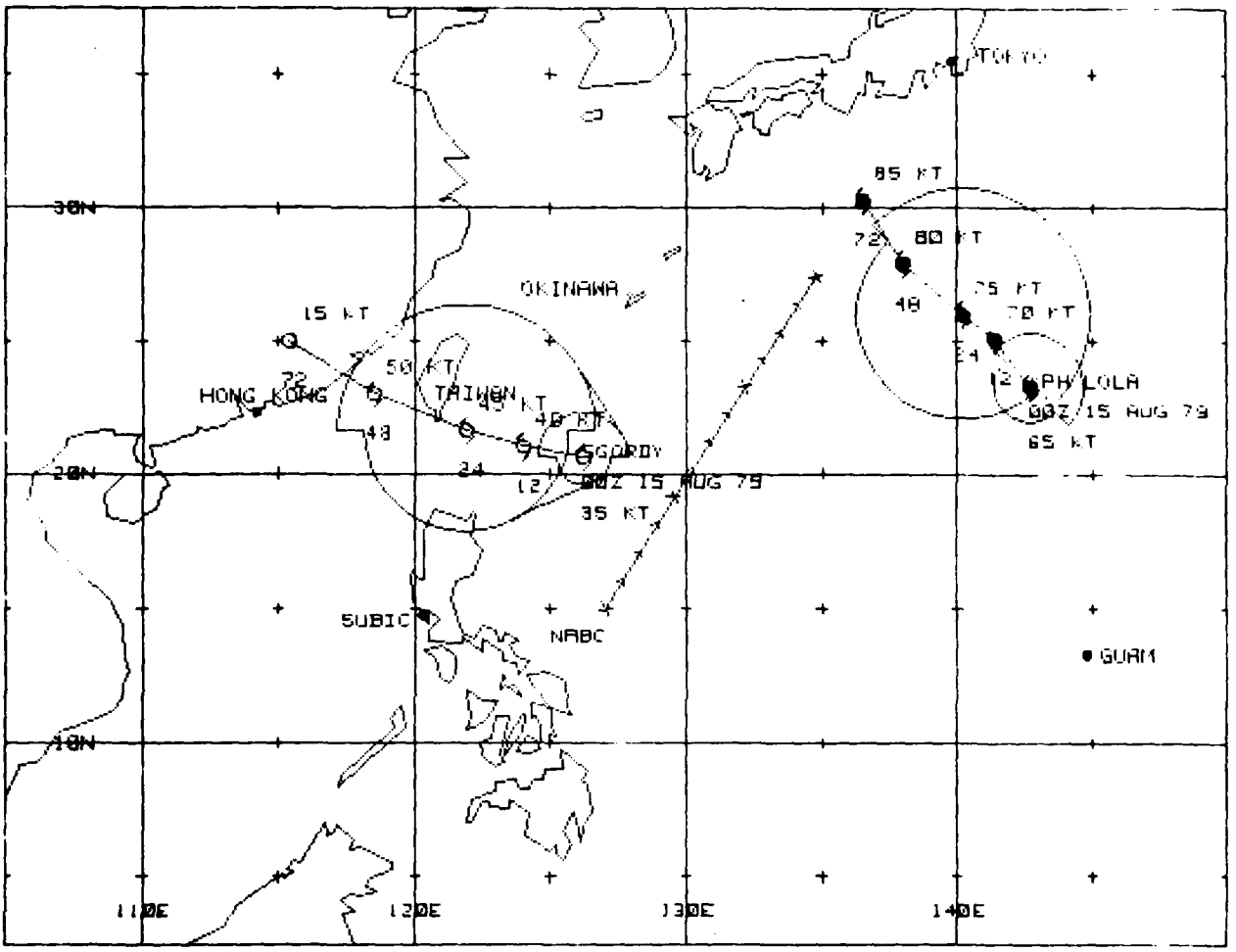


FIGURE 4-06. In this example, Options 1, 2, and 3 were selected to produce this product. Ship "NABC" is enroute from an area east of Luzon Island toward Tokyo at 12 kt. Tropical storm Gordy and Typhoon Lola pose possible threats. The close proximity of the ship to Typhoon Lola at 72 hours after the warning time suggests a high level of threat. Tropical storm Gordy indicates a minimum threat. Selection of the other options of TCASS provides the capability of reinforcing the subjective evaluation.

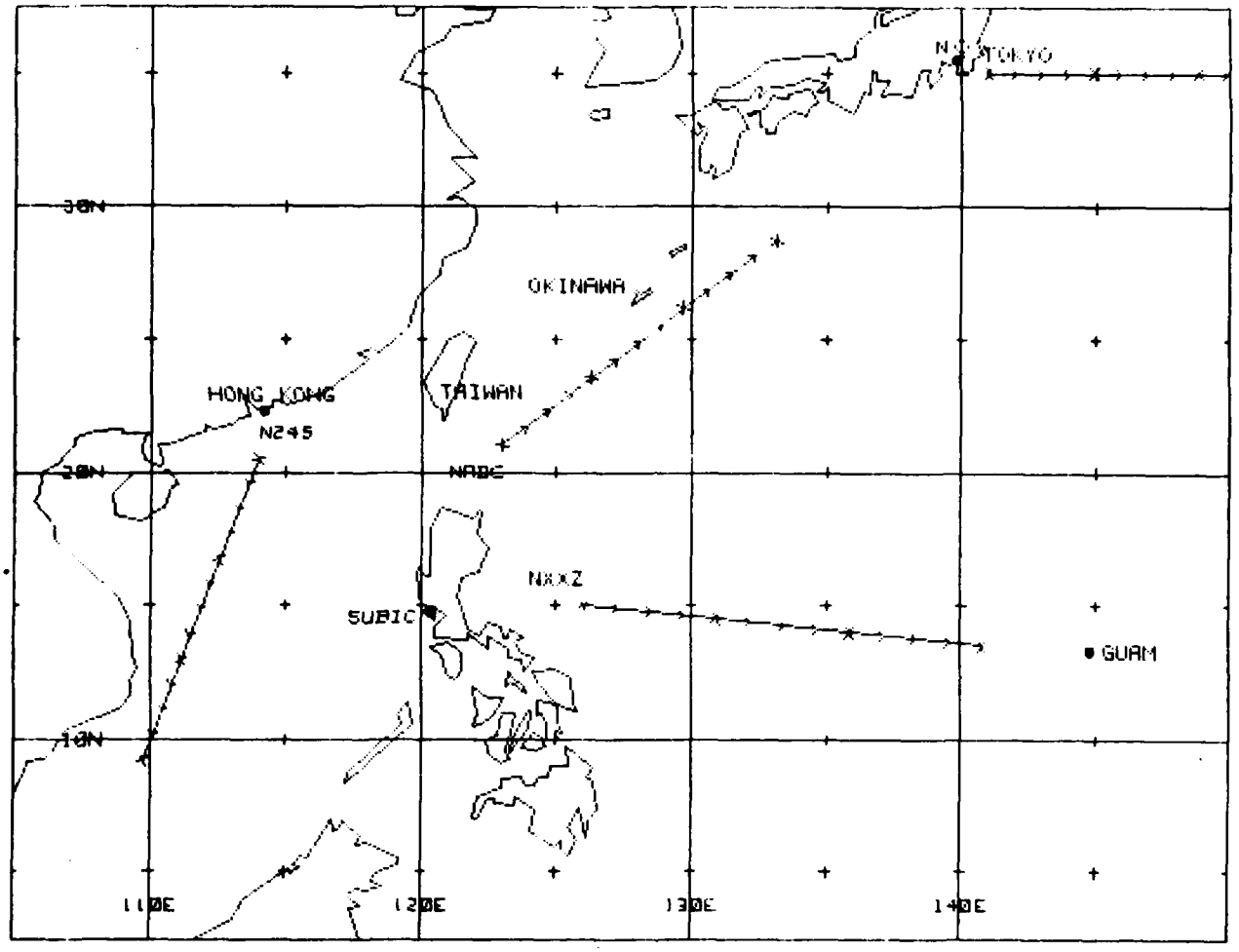


FIGURE 4-07. Example of the use of Option 3 in the selective mode for displaying the projected tracks of several ships for briefing purposes when no warnings are in effect.

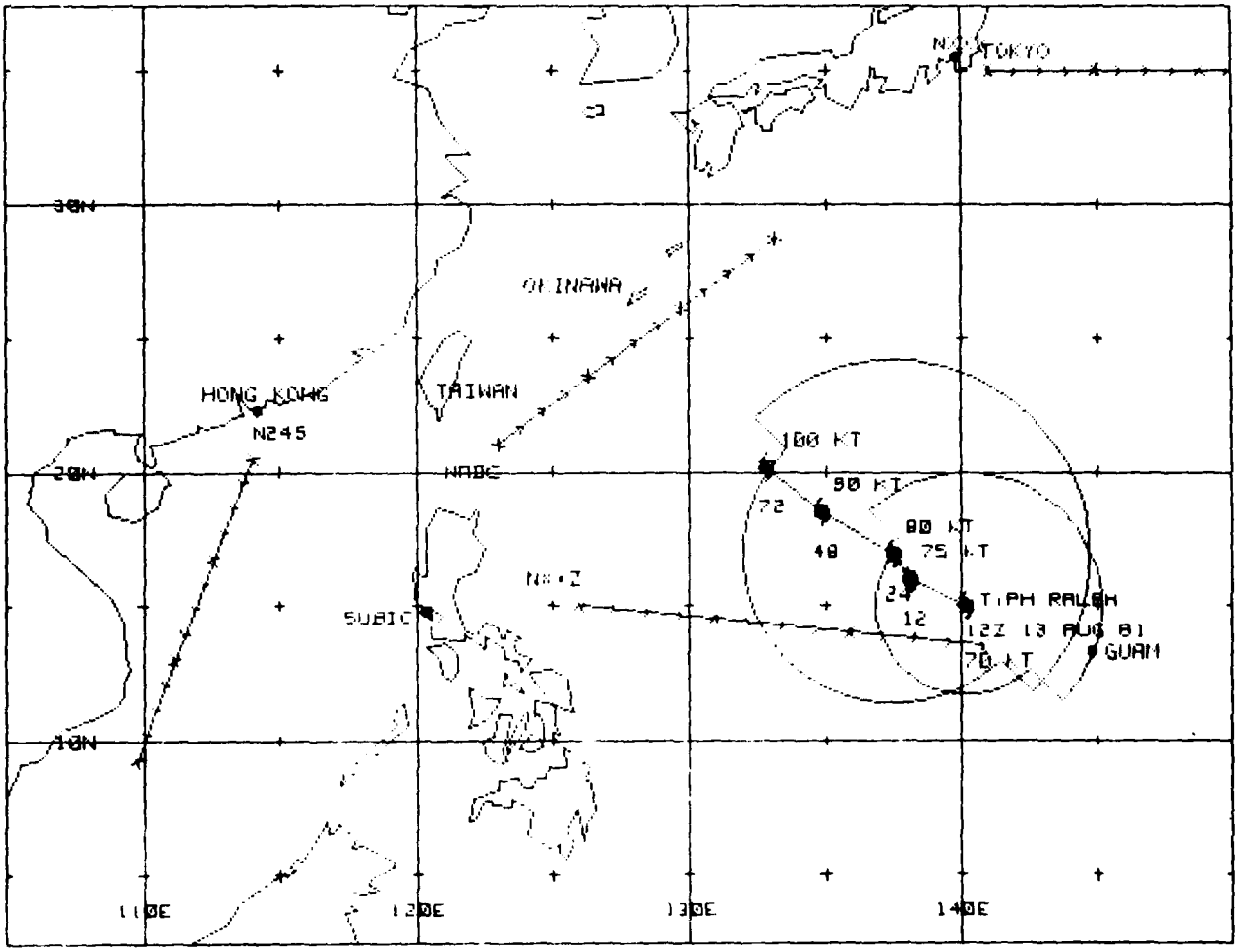


FIGURE 4-08. Similar to Figure 4-07 with a typhoon warning in effect and showing the "danger" area of 30 kt winds (produced using Options 1, 2, and 3 in the selective mode).

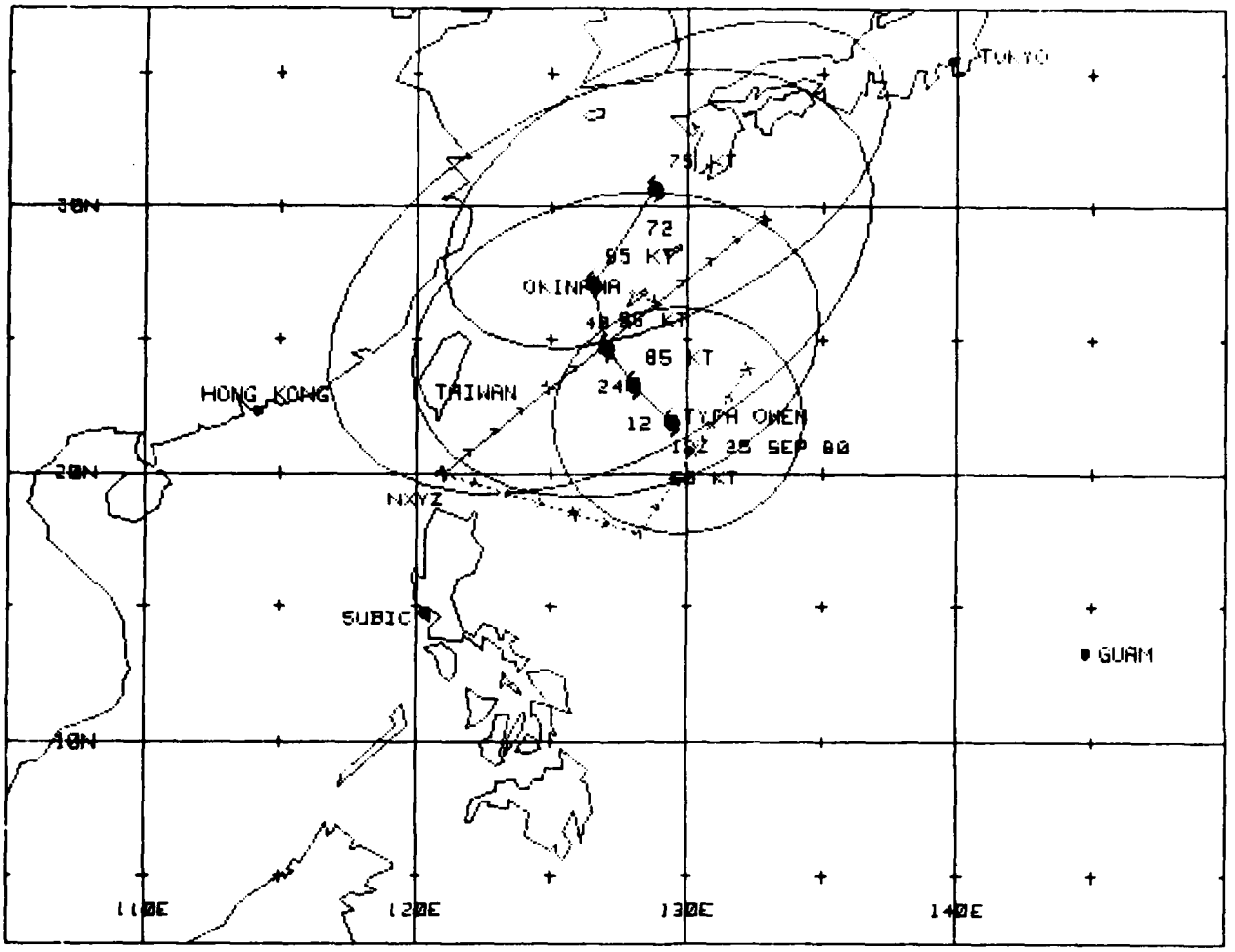
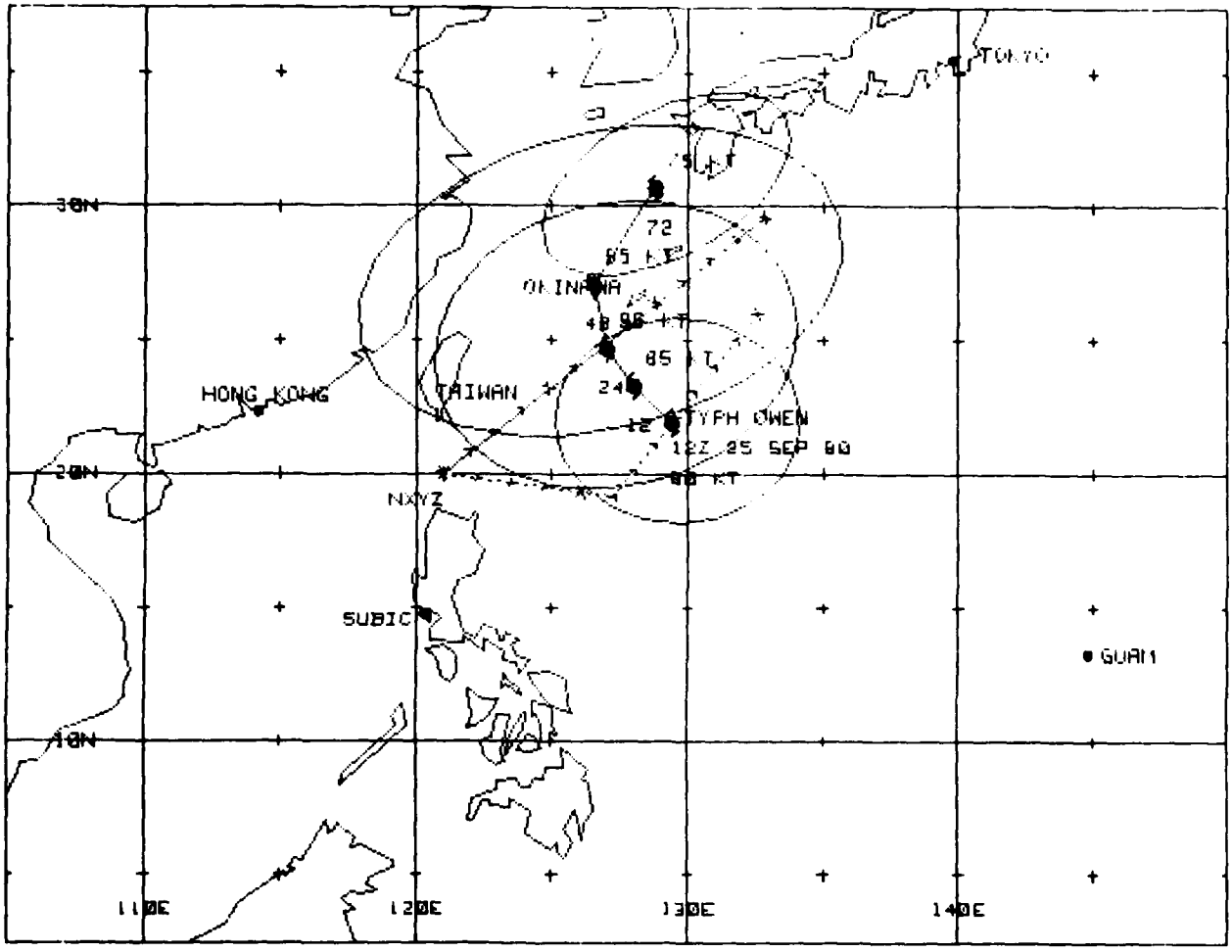


FIGURE 4-09. Example of alternative routing of ship "NXYZ" transiting the Bashi Channel toward Tokyo and threatened by typhoon Owen. The critical probability of 30 kt winds was set at 5% and only the critical probability isopleths of 30 kt winds were desired. This example is a result of Options 4, 5, and 6 in the selective mode.



10% PROBABILITY ISOPLETHS OF 30KT WINDS (SOLID LINES)

FIGURE 4-10. Same as Figure 4-09, except the critical probability of 30 kt winds was set at 10%. Note the relatively smaller area covered by the isopleths, and the less divergent alternative route.

SECTION 5. LIMITATIONS AND RECOMMENDATIONS

5.1 Limitations. The limitations of the initial version of TCASS are summarized as follows:

a. The application of the initial version of TCASS is restricted to the western North Pacific Ocean. The plot area is further limited to the geographical map background described in subsection 2.2.

b. The map background is not a true mercator projection and some distortion is present. However, the latitude/longitude calculations of the tropical cyclone positions and ship tracks are accurately represented.

c. There are no land-sea discrimination capabilities in the ship track and alternative routing processing.

d. The wind probability calculations are restricted to tropical cyclone winds only and do not infer any winds from the existing large scale synoptic situation, such as the tightening of the gradient between the subtropical ridge and the tropical cyclone or the influence of local topography as the tropical cyclone approaches land.

e. Sea and swell conditions are important factors to consider in tropical cyclone threat situations but are not incorporated into the current version of TCASS.

f. The wind probabilities calculated within TCASS are instantaneous probabilities of encountering 30 and 50 kt tropical cyclone winds at 6 hour intervals. Time integrated (cumulative) probabilities are not directly available.

g. Past history of the tropical cyclone warning positions is not saved for display.

5.2 Recommendations. The elimination of some of the above limitations are recommended in developing improvements to TCASS. A trade off between program size (and execution time) and the benefits derived must be considered in any enhancements to TCASS.

Applications to other geographical areas are currently undergoing development. TCASS versions for the North Atlantic Ocean, eastern North Pacific Ocean, and Indian Ocean are expected to be available within the near future. Inclusion of a true mercator background and the addition of past history are suggested as practical improvements. Overcoming the other limitations do not appear to be advantageous at this time.

Additional research and development efforts are needed before sea and swell information may be provided as a part of TCASS.

SECTION 6. REFERENCES

1. Jarrell, J. D., December 1978: Tropical Cyclone Strike Probability Forecasting. Naval Environmental Prediction Research Facility Contractor Report CR 78-01.

2. Jarrell, J. D., April 1981: Tropical Cyclone Wind Probability Forecasting (WINDP). Naval Environmental Prediction Research Facility Contractor Report CR 81-03.

3. Chin, D., K. Nuttall, M. McKim, H. Hamilton, and C. Buenafe, October 1980: Optimum Track Ship Routing (OTSR) Applications of the Tropical Cyclone Strike/Wind Probability Program. Naval Environmental Prediction Research Facility Contractor Report CR 80-04.

4. Systems and Applied Sciences Corporation, July 1981: Tropical Cyclone Applications Software System (TCASS) Users Manual - Western North Pacific Ocean. Naval Environmental Prediction Research Facility Shipboard Numerical Aids Program (SNAP) No. 7.

DISTRIBUTION

CINCLANTFLT
NORFOLK, VA 23511

CINCLANTFLT
NSAP SCI. ADV. (N04E)
NORFOLK, VA 23511

CINCPACFLT
PEARL HARBOR, HI 96860

COMSECONDFLT
FPO NEW YORK 09501

COMSECONDFLT
NSAP SCIENCE ADVISOR
FPO NEW YORK, 09501

COMTHIRDFLT
PEARL HARBOR, HI 96860

COMSEVENTHFLT
FLEET METEOROLOGIST (N30W)
FPO SAN FRANCISCO 96601

COMTHIRDFLT
NSAP SCIENCE ADVISOR
CODE N702/01T
PEARL HARBOR, HI 96860

COMSEVENTHFLT
NSAP SCIENCE ADVISOR
BOX 167
FPO SEATTLE 98762

COMMANDER
U.S. NAVAL FORCES, JAPAN
FPO SEATTLE 98762

COMMANDER
U.S. NAVAL FORCES, MARIANAS
FPO SAN FRANCISCO 96630

COMMANDER
U.S. NAVAL FORCES
BOX 30/N3, PHILIPPINES
FPO SAN FRANCISCO 96651

COMMANDER
U.S. NAVAL FORCES, KOREA
APO SAN FRANCISCO 96301

COMNAVAIRPAC
NAS, NORTH ISLAND
SAN DIEGO, CA 92135

COMNAVAIRPAC
NSAP SCIENCE ADV. (016)
NAS, NORTH ISLAND
SAN DIEGO, CA 92135

COMNAVSURFLANT
NSAP SCIENCE ADV. (N009)
NORFOLK, VA 23511

COMNAVSURFPAC
CODE N331A, NAVAL AMPHIBIOUS
BASE, CORONADO
SAN DIEGO, CA 92155

COMMANDER
MINE WARFARE COMMAND
NSAP SCIENCE ADV. (007)
CHARLESTON, SC 29408

COMSUBLANT
NSAP SCIENCE ADV. (013)
NORFOLK, VA 23511

COMSUBPAC
NSAP SCIENCE ADV. (009)
PEARL HARBOR, HI 96860

COMMANDER
AMPHIBIOUS GROUP 2
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09501

COMMANDER
AMPHIBIOUS GROUP 1
ATTN: METEOROLOGICAL OFFICER
FPO SAN FRANCISCO 96601

COMMANDER
NAVAL SURFACE GROUP, MIDPAC
PEARL HARBOR, HI 96860

COMMANDER
NAVAL SURFACE GROUP, WESTPAC
FPO SAN FRANCISCO 96601

COMMANDING OFFICER
USS AMERICA (CV-66)
ATTN: MET. OFFICER, OA DIV.
FPO NEW YORK 09531

COMMANDING OFFICER
USS FORRESTAL (CV-59)
ATTN: MET. OFFICER, OA DIV.
FPO MIAMI 34080

COMMANDING OFFICER
USS INDEPENDENCE (CV-62)
ATTN: MET. OFFICER, OA DIV.
FPO NEW YORK 09537

COMMANDING OFFICER
USS J. F. KENNEDY (CV-67)
ATTN: MET. OFFICER, OA DIV.
FPO NEW YORK 09538

COMMANDING OFFICER
USS NIMITZ (CVN-68)
ATTN: MET. OFFICER, OA DIV.
FPO NEW YORK 09542

COMMANDING OFFICER
USS D. D. EISENHOWER, CVN-69
ATTN: MET. OFFICER, OA DIV.
FPO NEW YORK 09532

COMMANDING OFFICER
USS CARL VINSON (CVN-70)
ATTN: MET. OFFICER, OA DIV.
FPO NEW YORK 09558

COMMANDING OFFICER
USS SARATOGA (CV-60)
ATTN: MET. OFFICER, OA DIV.
FPO NEW YORK 09587

COMMANDING OFFICER
USS CONSTELLATION (CV-64)
ATTN: MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96635

COMMANDING OFFICER
USS CORAL SEA (CV-43)
ATTN: MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96632

COMMANDING OFFICER
USS ENTERPRISE (CVN-65)
ATTN: MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96636

COMMANDING OFFICER
USS KITTY HAWK (CV-63)
ATTN: MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96634

COMMANDING OFFICER
USS MIDWAY (CV-41)
ATTN: MET. OFFICER, OA DIV.
FPO SAN FRANCISCO 96631

COMMANDING OFFICER
USS RANGER (CV-61)
ATTN: METEOROL OFFICER, OA DIV
FPO SAN FRANCISCO 96633

COMMANDING OFFICER
USS MOUNT WHITNEY, LCC-20
ATTN: MET. OFFICER
FPO NEW YORK 09517

COMMANDING OFFICER
USS BLUE RIDGE (LCC-19)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96628

COMMANDING OFFICER
USS GUADALCANAL (LPH-7)
ATTN: MET. OFFICER
FPO NEW YORK 09562

COMMANDING OFFICER
USS GUAM (LPH-9)
ATTN: MET. OFFICER
FPO NEW YORK 09563

COMMANDING OFFICER
USS INCHON (LPH-12)
ATTN: MET. OFFICER
FPO NEW YORK 09529

COMMANDING OFFICER
USS IWO JIMA (LPH-2)
ATTN: MET. OFFICER
FPO NEW YORK 09561

COMMANDING OFFICER
USS NASSAU (LHA-4)
ATTN: MET. OFFICER
FPO NEW YORK 09557

COMMANDING OFFICER
USS SAIPAN (LHA-2)
ATTN: MET. OFFICER
FPO NEW YORK 09549

COMMANDING OFFICER
USS NEW ORLEANS (LPH-11)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96627

COMMANDING OFFICER
USS OKINAWA (LPH-3)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96625

COMMANDING OFFICER
USS TRIPOLI (LPH-10)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96626

COMMANDING OFFICER
USS TARAWA (LHA-1)
FPO SAN FRANCISCO 96622

COMMANDING OFFICER
USS BELLEAU WOOD (LHA-3)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96623

COMMANDING OFFICER
USS PELELIU (LHA-5)
FPO SAN FRANCISCO 96624

COMMANDING OFFICER
USS PUGET SOUND (AD-38)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09544

COMMANDING OFFICER
USS LASALLE (AGF-3)
ATTN: METEOROLOGICAL OFFICER
FPO NEW YORK 09577

COMMANDER
NAVAL SURFACE FORCE
U.S. PACIFIC FLEET
NSAP SCI. ADV., 005/N6N
SAN DIEGO, CA 92155

COMMANDING OFFICER
USS POINT LOMA (AGDS-2)
ATTN: MET. OFFICER
FPO SAN FRANCISCO 96677

CINCPAC
BOX 13
STAFF CINCPAC J37
CAMP SMITH, HI 96861

SPECIAL ASST. TO THE ASST.
SECNAV (R&D)
RM. 43741, THE PENTAGON
WASHINGTON, DC 20350

CHIEF OF NAVAL RESEARCH (2)
LIBRARY SERVICES, CODE 734
RM. 633, BALSTON TOWER #1
800 QUINCY ST.
ARLINGTON, VA 22217

CHIEF OF NAVAL OPERATIONS
OP-952
U.S. NAVAL OBSERVATORY
WASHINGTON, DC 20390

CHIEF OF NAVAL OPERATIONS
OP-986, NAVY DEPT.
WASHINGTON, DC 20350

CHIEF OF NAVAL OPERATIONS
DR. R. W. JAMES, OP-952D1
U.S. NAVAL OBSERVATORY
34TH & MASS. AVE., NW
WASHINGTON, DC 20390

CHIEF OF ENV. SVCS. DIV.
OJCS (J-33)
RM. 2877K, THE PENTAGON
WASHINGTON, DC 20301

DET. 2, HQ. AWS
THE PENTAGON
WASHINGTON, DC 20330

NAVAL DEPUTY TO THE ADMIN.
NOAA, ROOM 200
PAGE BLDG. #1
3300 WHITEHAVEN ST. NW
WASHINGTON, DC 20235

OFFICER IN CHARGE
NAVOCEANCOMDET
BOX 81
U.S. NAVAL AIR STATION
FPO SAN FRANCISCO 96637

OFFICER IN CHARGE
NAVOCEANCOMDET
FEDERAL BLDG.
ASHEVILLE, NC 28801

OFFICER IN CHARGE
NAVOCEANCOMDET
U.S. NAVAL AIR FACILITY
FPO SEATTLE 98767

OFFICER IN CHARGE
NAVOCEANCOMDET
NAVAL AIR STATION
BARBERS PT., HI 96862

OFFICER IN CHARGE
NAVOCEANCOMDET
NAVAL STATION
CHARLESTON, SC 29408

COMMANDING OFFICER
NAVOCEANCOMFAC
BOX 63
U.S. NAVAL AIR STATION
FPO SAN FRANCISCO 96654

OFFICER IN CHARGE
U.S. NAVOCEANCOMDET
BOX 16
FPO NEW YORK 09593

OFFICER IN CHARGE
NAVOCEANCOMDET
BOX 9048
NAVAL AIR STATION
KEY WEST, FL 33040

CPOIC
NAVOCEANCOMDET
NAVAL AIR STATION
MAYPORT, FL 32228

OFFICER IN CHARGE
U.S. NAVOCEANCOMDET
NAVAL AIR FACILITY, BOX 35
FPO SAN FRANCISCO 96614

OFFICER IN CHARGE
U.S. NAVOCEANCOMDET
APO SAN FRANCISCO 96519

CPOIC
NAVOCEANCOMDET
NAVAL AIR STATION
NEW ORLEANS, LA 70146

OFFICER IN CHARGE
NAVOCEANCOMDET
AFGWC
OFFUTT AB, NE 68113

OFFICER IN CHARGE
NAVOCEANCOMDET
U.S. NAVAL STATION
FPO MIAMI 34051

OFFICER IN CHARGE
NAVOCEANCOMDET
NAS, OCEANA
VIRGINIA BEACH, VA 23460

OFFICER IN CHARGE
U.S. NAVOCEANCOMDET
FPO SAN FRANCISCO 96685

OFFICER IN CHARGE
NAVOCEANCOMDET
U.S. FLEET ACTIVITIES
FPO SEATTLE 98770

OFFICER IN CHARGE
NAVOCEANCOMDET
NAVAL AIR STATION
PENSACOLA, FL 32508

OFFICER IN CHARGE
NAVOCEANCOMDET
MONTEREY, CA 93940

COMMANDING OFFICER
NAVAL RESEARCH LAB
ATTN: LIBRARY, CODE 2620
WASHINGTON, DC 20390

COMMANDING OFFICER
OFFICE OF NAVAL RESEARCH
EAST/CENTRAL REGIONAL OFFICE
BLDG. 114 SECTION D
459 SUMMER ST.
BOSTON, MA 02210

COMMANDING OFFICER
NOROA, CODE 101
NSTL STATION
BAY ST. LOUIS, MS 39529

COMMANDING OFFICER
FLT INTELLIGENCE CENTER, PAC
PEARL HARBOR, HI 96860

COMNAVOCEANCOM
NSTL STATION
BAY ST. LOUIS, MS 39529

COMNAVOCEANCOM
ATTN: J. W. OWNBEY (N542)
NSTL STATION
BAY ST. LOUIS, 39529

COMMANDING OFFICER
NAVOCEANO, LIBRARY
NSTL STATION
BAY ST. LOUIS, MS 39522

COMMANDING OFFICER
FLENUMOCEANCEN
MONTEREY, CA 93940

COMMANDING OFFICER
NAVWESTOCEANCEN
BOX 113
PEARL HARBOR, HI 96860

COMMANDING OFFICER
NAVEASTOCEANCEN
MCADIE BLDG. (U-117)
NAVAL AIR STATION
NORFOLK, VA 23511

COMMANDING OFFICER
NAVPOLAROCEANCEN
4301 SUITLAND RD.
WASHINGTON, DC 20390

COMMANDING OFFICER
U.S. NAVOCEANCOMCEN
BOX 12
COMNAVMARIANAS
FPO SAN FRANCISCO 96630

COMMANDING OFFICER
U.S. NAVOCEANCOMCEN
BOX 31
FPO NEW YORK 09540

COMMANDING OFFICER
NAVOCEANCOMFAC
P.O. BOX 85, NAS
JACKSONVILLE, FL 32212

COMMANDING OFFICER
NAVOCEANCOMFAC
NAS, NORTH ISLAND
SAN DIEGO, CA 92135

COMMANDING OFFICER
U.S. NAVOCEANCOMFAC
FPO SEATTLE 98762

CHAIRMAN, OCEANOGRAPHY DEPT.
U.S. NAVAL ACADEMY
ANNAPOLIS, MD 21402

PRESIDENT
NAVAL WAR COLLEGE
ATTN: GEOPHYSICS OFFICER
NEWPORT, RI 02840

COMMANDER
NAVAL SAFETY CENTER
NAVAL AIR STATION
NORFOLK, VA 23511

COMNAVAIRSYSCOM
ATTN: LIBRARY, AIR-00D4
WASHINGTON, DC 20361

COMNAVAIRSYSCOM
AIR-370
WASHINGTON, DC 20361

COMNAVAIRSYSCOM
METEORO. SYS. DIV., AIR-553
WASHINGTON, DC 20360

COMNAVAIRSYSCOM
AIR-03, DEPT. OF THE NAVY
WASHINGTON, DC 20361

COMMANDER
NAVAL SHIP RSCH & DEV. CENTER
SURFACE SHIP DYNAMICS BRANCH
ATTN: S. BALES
BETHESDA, MD 20084

DIRECTOR
NAVY SCIENCE ASSIST. PROGRAM
NAVSURFWEACEN, WHITE OAKS
SILVER SPRING, MD 20910

COMMANDER
PACMISTESTCEN
GEOPHYSICS OFFICER (3250)
PT. MUGU, CA 93042

CHIEF OF NAVAL
EDUCATION & TRAINING
NAVAL AIR STATION
PENSACOLA, FL 32508

COMMANDING OFFICER
AMPHIBIOUS WARFARE LIBRARY
NAVAL AMPHIBIOUS SCHOOL
NORFOLK, VA 23521

COMMANDING OFFICER
NAVPHIBSCOL, CORONADO
SAN DIEGO, CA 92155

NAVAL POSTGRADUATE SCHOOL
METEOROLOGY DEPT., CODE 63
MONTEREY, CA 93940

NAVAL POSTGRADUATE SCHOOL
OCEANOGRAPHY DEPT., CODE 68
MONTEREY, CA 93940

NAVAL POSTGRADUATE SCHOOL
LIBRARY
MONTEREY, CA 93940

COMMANDING OFFICER
U.S. MCAS (HELICOPTER)
ATTN: WEATHER SERVICE OFFICE
FPO SEATTLE 98772

COMMANDING OFFICER
U.S. MCAS
ATTN: WEATHER SERVICE OFFICE
FPO SEATTLE 98764

COMMANDING OFFICE
MCAS
ATTN: WEATHER SERVICE OFFICE
KANEOHE BAY, HI 96863

COMMANDER
AWS/DN
SCOTT AFB, IL 62225

USAFETAC/TS
SCOTT AFB, IL 62225

3350TH TECH. TRNG. GROUP
TTGU-W/STOP 623
CHANUTE AFB, IL 61868

AFGL/LY
HANSCOM AFB, MA 01731

5WW/DN
LANGLEY AFB, VA 23665

DIRECTOR, PAC. HURRI. CEN.
NWS, NOAA, CENTRAL
HONOLULU, HI 96[illegible]

OFFICER IN CHARGE
SERV. SCOL. COM., GREAT LAKES
DET. CHANUTE/STOP 62
CHANUTE AFB, IL 61868

HQ 1ST WW/DN
HICKAM AFB, HI 96853

DET 4 HQ AWS/CC
APO SAN FRANCISCO 96334

DET 5 1WW/CC
APO SAN FRANCISCO 96274

DET 8, 30 WS
APO SAN FRANCISCO 96239

DET 17, 30 WS
APO SAN FRANCISCO 96328

DET 18, 30 WS
APO SAN FRANCISCO 96301

CHIEF
AEROSPACE SCIENCE BRANCH
HQ. 1ST ww (MAC)
HICKAM AFB, HI 96853

DIRECTOR (12)
DEFENSE TECH. INFO. CENTER
CAMERON STATION
ALEXANDRIA, VA 22314

DIRECTOR
OFFICE OF ENV. & LIFE SCI.
OFFICE OF THE UNDERSEC OF
DEFENSE FOR RSCH & ENG (E&LS)
RM. 3D129, THE PENTAGON
WASHINGTON, DC 20301

CHIEF, MARINE SCIENCE SECTION
U.S. COAST GUARD ACADEMY
NEW LONDON, CT 06320

COMMANDING OFFICER
USCGC GLACIER (WAGB-4)
FPO SAN FRANCISCO 96601

COMMANDING OFFICER
USCG RSCH & DEVEL. CENTER
GROTON, CT 06340

DIRECTOR
NATIONAL METEORO. CENTER
NWS/NOAA, ROOM 204
WORLD WEATHER BLDG. W32
WASHINGTON, DC 20233

ACQUISITIONS SECTION IRDB-D823
LIBRARY & INFO. SERV. DIV.
NOAA, 6009 EXECUTIVE BLVD.
ROCKVILLE, MD 20852

DIRECTOR
OFFICE OF PROGRAMS RX3
NOAA RSCH LAB
BOULDER, CO 80302

DIRECTOR
NATIONAL HURRICANE CENTER
1320 S. DIXIE HWY
CORAL GABLES, FL 33146

NATIONAL CLIMATIC CENTER
ATTN: E. PRESTON D542X2
FEDERAL BLDG. -LIBRARY
ASHEVILLE, NC 28801

CHIEF, SCIENTIFIC SERVICES
NWS, NOAA WESTERN REGION
P.O. BOX 11188, FEDERAL BLDG
SALT LAKE CITY, UT 84111

CHIEF, SCIENTIFIC SERVICES
NWS, PACIFIC REGION
P.O. BOX 50027
HONOLULU, HI 96850

DIRECTOR, (OAX4), NOAA
6010 EXECUTIVE BLVD.
ROCKVILLE, MD 20852

DIRECTOR (AOML)
NATIONAL HURRICANE RSCH. LAB.
1320 S. DIXIE HWY.
CORAL GABLES, FL 33146

HEAD, ATMOS. SCIENCES DIV.
NATIONAL SCIENCE FOUNDATION
1800 G. STREET, NW
WASHINGTON, DC 20550

PRELIM. SYSTEMS DESIGN GROUP
NASA GODDARD SPACE FLIGHT CEN.
GREENBELT, MD 20771

EXECUTIVE SECRETARY
CAO SUBCOMMITTEE ON
ATMOS. SCIENCES, NSF
ROOM 510
1800 G. STREET NW
WASHINGTON, DC 20550

COLORADO STATE UNIVERSITY
ATMOS. SCIENCES DEPT.
ATTN: LIBRARIAN
FT. COLLINS, CO 80521

CHAIRMAN
METEOROLOGY DEPT.
PENN STATE UNIVERSITY
503 DEIKE BLDG.
UNIVERSITY PARK, PA 16802

CHAIRMAN
METEOROLOGY DEPT.
MASSACHUSETTS INST. OF TECH.
CAMBRIDGE, MA 02139

DIRECTOR
INSTITUTE OF GEOPHYSICS
UCLA
LOS ANGELES, CA 90024

UNIVERSITY OF WASHINGTON
ATMOSPHERIC SCIENCES DEPT.
SEATTLE, WA 98195

FLORIDA STATE UNIVERSITY
ENVIRONMENTAL SCIENCES DEPT.
TALLAHASSEE, FL 32306

UNIVERSITY OF HAWAII
METEOROLOGY DEPT.
2525 CORREA RD.
HONOLULU, HI 96822

CHAIRMAN
METEOROLOGY DEPT.
UNIV. OF WISCONSIN
1225 W. DAYTON STREET
MADISON, WI 53706

TEXAS A&M UNIVERSITY
METEOROLOGY DEPT.
COLLEGE STATION, TX 77843

CHAIRMAN
METEOROLOGY DEPT.
UNIVERSITY OF OKLAHOMA
NORMAN, OK 73069

CHAIRMAN
METEOROLOGY DEPT.
CALIFORNIA STATE UNIVERSITY
SAN JOSE, CA 95192

DOCUMENTS/REPORTS SECTION
LIBRARY
SCRIPPS INST. OF OCEANOGRAPHY
LA JOLLA, CA 92037

CHAIRMAN
ATMOSPHERIC SCIENCES DEPT.
UNIVERSITY OF VIRGINIA
CHARLOTTESVILLE, VA 22903

UNIVERSITY OF MARYLAND
METEOROLOGY DEPT.
COLLEGE PARK, MD 20742

ST. LOUIS UNIVERSITY
EARTH & ATMOS. SCIENCE DEPT.
P.O. BOX 8099-LACLEDE STN.
ST. LOUIS, MO 63156

THE EXECUTIVE DIRECTOR
AMERICAN METEORO. SOCIETY
45 BEACON ST.
BOSTON, MA 02108

AMERICAN METEORO. SOCIETY
MET. & ASTROPHYS. ABSTRACT
P.O. BOX 1736
WASHINGTON, DC 20013

DIRECTOR, JTWC
BOX 17
FPO SAN FRANCISCO 96630

WORLD METEORO. ORGANIZATION
ATTN: N. SUZUKI, ATS DIV.
CH-1211, GENEVA 20,
SWITZERLAND

BUREAU OF METEOROLOGY
ATTN: LIBRARY
BOX 1289K, GPO
MELBOURNE, VIC, 3001
AUSTRALIA

DIRECTOR OF NAVAL OCEANOGRAPHY
& METEOROLOGY
MINISTRY OF DEFENCE
OLD WAR OFFICE BLDG.
LONDON, S.W.1. ENGLAND

METEOROLOGICAL OFFICE LIBRARY
LONDON ROAD
BRACKNELL, BERKSHIRE
RG 12 2SZ, ENGLAND

COMMANDER IN CHIEF FLEET
ATTN: STAFF METEOROLOGIST &
OCEANOGRAPHY OFFICER
NORTHWOOD
MIDDLESEX HP6 3HP
ENGLAND

DIRECTOR
ROYAL OBSERVATORY
NATHAN ROAD, KOWLOON
HONG KONG, B.C.C.

DIRECTOR GENERAL
METEOROLOGICAL DEPT.
GOVERNMENT OF INDIA
NEW DELHI, 3 INDIA

TYPHOON RESEARCH LAB.
ATTN: LIBRARIAN
METEORO. RESEARCH INSTITUTE
1-1 NAGAMINE, YATABE-MACHI,
TSUKUBA-GUN
IBARAKI-KEN, 305, JAPAN

JAPAN METEOROLOGICAL AGENCY
3-4, OTEMACHI 1-CHOME,
CHIYODA-KU TOKYO 100, JAPAN

METEOROLOGY DEPT.
COLLEGE OF ARTS & SCIENCES
UNIVERSITY OF THE PHILIPPINES
DILMAN, QUEZON CITY 3004
PHILIPPINES

TECHNICAL LIBRARY
WEATHER BUREAU
NATIONAL DEFENSE DEPT.
LUNGSOD NG QUEZON
PHILIPPINES

NATIONAL WEATHER SERVICE
ATMOS. GEOPHYS. & ASTRONOMICAL
SERVICES ADMIN. (PAGASA)
1424 QUEZON AVE.
QUEZON CITY, METRO MANILA
PHILIPPINES

DIRECTOR
TYPHOON MODERATION RSCH. &
DEVELOPMENT OFFICE, PAGASA
MINISTRY OF NATIONAL DEFENSE
1424 QUEZON AVE.
QUEZON CITY, PHILIPPINES

COORDINATOR, ESCAP/WMO
TYPHOON COMMITTEE SECRETARIAT
C/O UNDP
MANILA, PHILIPPINES

CHIEF, ATMOS. SCIENCES DIV.
WORLD METEORO. ORGANIZATION
GENEVA 20, SWITZERLAND

CENTRAL WX BUREAU
64, KUNG YUAN RD.
TAIPEI, TAIWAN 100

ATMOSPHERIC SCIENCES DEPT.
NATIONAL TAIWAN UNIVERSITY
TAIPEI, TAIWAN 107